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How and why to achieve greater objectivity in taxonomy, exemplified by a fossil ostracod (*Amplocypris abscissa*) from the Miocene Lake Pannon

This contribution is dedicated to Professor Dr. Angel Baltanás for his 50th birthday.

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Abstract: A project on fossil ostracods from Hennersdorf (Vienna Basin, Middle Pannonian "E" stage) documents the non-marine ostracod *Amplocypris abscissa* (Reuss 1850) as a polymorphic taxon. The high morphological variability of the valves belonging to this species and its geographic distribution in the Lake Pannon point to a widely spread fossil taxon. This traditional view emerges from the fact that A. abscissa displays few homologous "landmarks" (morphological reference points) which makes it difficult to compare morphotypes within and among populations. The present contribution offers arguments for the need of objective criteria when describing ostracods with few visible morphological traits. It is demonstrated that using a composite algorithmic approach which combines information implemented in the computer programme MORPHOMATICA for different variables, measured on interval and ratio scales, is able to define morphological traits objectively. The data analysed with multivariate statistics are further used for diagnostic profiles of clearly delineated morphotypes. The potential taxonomic value of three morphotypes here identified for *Amplocypris abscissa* is discussed. It is argued that this taxon represents a phylogenetic lineage within which a cluster of species with discrete morphological traits exists. Finally, it is proposed to apply similar algorithms for the necessary revision of the whole group of *Amplocypris* species from Lake Pannon.

Key Words: Fossil Ostracoda; Comparative Morphology; Geometric Morphometrics; Taxonomy; Lake Pannon; Late Miocene.

1. Introduction

1.1. Objectivity

Objectivity is a term generally understood as the ability of describing things without reference to individual (idiosyncratic) interpretations. This concept is commonly perceived as controversial. This is due to the fact that within human experience and implicitly in the act of perception and those of critical interpretation of the information a more-or-less implicit relationship between subject and object, respectively between knower and known exists (von Foerster 2005). In the present context we use the term objectivity as the act of achieving precise descriptions of our objects of study following well established protocols and/or algorithms. These latter should be easily understood and, when necessary, repeated for verification and further critical interpretation. Only in this way can our data become a matter for serious discussion which should allow conceptual and/or practical advances within our field of research. With other words we express here what the American philosopher Dewey (1929: 28) wrote: "*The scientific investigator convinces others that not by plausibility of his definitions and the cogency of his dialectic, but by placing before them the specified course of searchings, doings and arrivals, in consequence of which certain things have been found. His appeal is for others to traverse a similar course, so as to see how what they find corresponds with his report*". It is important to underline that in the present project the selected procedures for study and their usage and interpretation are the product of extended experience and practice we have developed in recent years. It should be understood as a kind of "personal knowledge" as conceived by Polanyi (1958). This author defends the epistemic concept of verifiability of scientific ideas. This point of view differs markedly from the way the well known palaeontologist G.G. Simpson (1961) defined the concepts of objectivity versus those of subjectivity when dealing with animal taxa. For Simpson (1961: 114) organisms are real, objective, entities while "*the concept of a taxon [...] is invariably subjective*". The present contribution tries to demonstrate that it is possible to use instead of subjective views for conceptual problems, as those occurring in animal taxonomy, "transparent" arguments which help to accept within a scientific discourse the objectivity of ideas.

1.2. The specific problem related to the taxonomic status of the fossil ostracod *Amplocypris abscissa* (Reuss)

Taxonomists are commonly confronted with incomplete descriptions. The situation is exacerbated for fossil taxa which display few homologous 'landmarks' (morphological reference points) useful for defining morphological traits. These latter are necessary for building clear taxonomic diagnosis, for phylogenetic analysis or for projects dealing with (palaeo)ecology, (palaeo)biogeography or (bio)stratigraphy.

Amplocypris abscissa was briefly described by A.E. Reuss (1850) from several outcrops near Vienna and Sopron, respectively from the Vienna and the Eisenstadt-Sopron basins (Late Miocene, Pannonian). Subsequently, it was mentioned (cf. *inter alia* Mehes 1907; Pokorný 1952; Olteanu 1971; 1986; Sokač 1972; Krstić 1973; Jiriček 1985; Zelenka 1989, 1992; Vasiliev et al. 2010) all around the palaeo-Lake Pannon. This latter was a giant limnic system which was extended during the Late Miocene from the western sites now in Austria, Hungary, Slovakia, parts of Czech Republic, to eastern and southern ones, respectively Romania, Serbia, Croatia, Slovenia (cf. MAGYAR et al. 1999a and here Fig. 5). The wide geographic distribution of one *Amplocypris* species contrasts with the high number of fossil species belonging to this genus, considered to be endemic to Lake Pannon (KRSTIĆ 1973). Therefore the question we ask is if *Amplocypris abscissa* is really a species extensively distributed in Lake Pannon or if it represents a cluster of species, each with discrete morphologic traits and more-or-less restricted geographic distribution.

1.3. The A.E. REUSS' description of *Amplocypris abscissa* in "Die fossilen Entomostraceen des Österreichischen Tertiärbeckens"

The monograph of A.E. REUSS "Die fossilen Entomostraceen des Österreichischen Tertiärbeckens" (1850) is a milestone for the documentation of the Late Miocene age ostracods of the Vienna Basin during the Pannonian (cf. ZORN 1999). REUSS described and illustrated 90 species from which 80 were new to science. The illustration is obviously poor and the systematics simplistically resolved.

REUSS (1850) described the right valve of *A. abscissa* as being large (1.5 mm long), with the posterior third elongated and postero-ventrally angular shaped, from where also the name originates (Fig. 1A, B).

The first sampling site mentioned in the description is an area located between Atzgersdorf and Altmannsdorf, in the southern part of today's Vienna. The next locality mentioned by REUSS is Sopron in Hungary (at the time named Ödenburg).

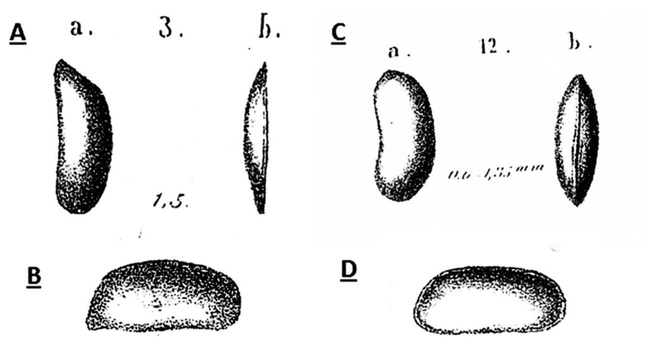

Fig. 1: Details of original figures of the REUSS' monograph; A, B – *Amplocypris abscissa* (REUSS); C, D – *Amplocypris recta* (REUSS). Note that the orientation of valves in the original plate 8 of REUSS for A (Fig. 3 in REUSS) and C (Fig. 12 in REUSS) are with the posterior towards the top extremity up-set. Here the correct orientation of the right valves in B (Fig. 2a in REUSS) and D (Fig. 11a in REUSS) follows the present-day practice standards.

A part of the original sediment material of Reuss' collection still exists at the Natural History Museum Vienna (NHMW), Geological–Palaeontological Department. We were able to recover several valves of this species from the material of Sopron (Ödenburg; cf. Annex 1, Tab. 1), which are much similar to the Lectotype here presented (see 1.4.).

1.4. The documentation of *Amplocypris abscissa* by K. Turnovsky and A. Papp

During 1946 and 1950 A. Papp and E. Thenius (cf. their 1954 monograph) produced a micro- and macro-palaeontological study on the Late Miocene environment in the Vienna area, especially at Vösendorf. Papp & K. Turnovsky (1950) identified *A. abscissa* of Reuss at Leobersdorf and attributed it to the genus *Herpetocypris* Brady & Norman.

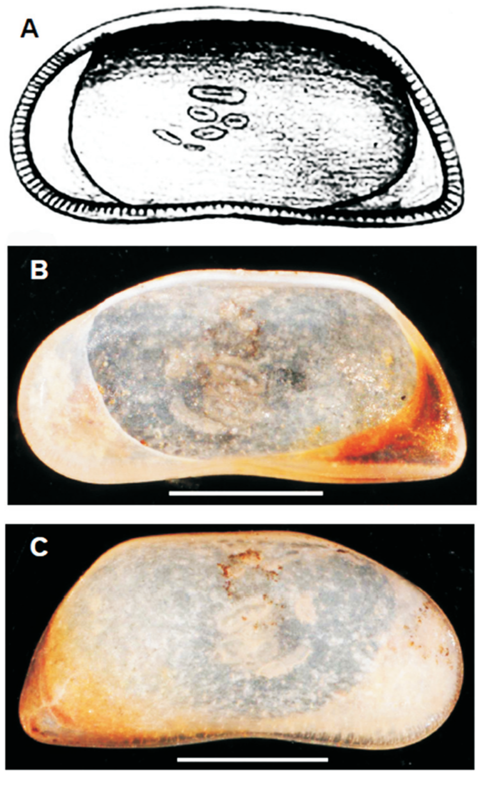

Fig. 2: Amplocypris abscissa, right valve; A, B – inner side; C – outer side; A – figure reproduced from Turnovsky (1954, Pl. 14, Fig. 13b, det. A. Papp); B, C – Lectotype NHMW-2011/0158/0003 (Atzgersdorf); scale bar = 0.5 mm.

Figures of their material were drawn by A. Papp and circulated in an unpublished report (1949) of Turnovsky: "*Die marinen und sarmatischen Ostracoden des Wiener Beckens; Revision der Reussischen Arbeit*" (deposited in the library of the Geological Survey in Vienna, Document A 00508 R 1981) and later on published by Turnovsky, in Grill & Küpper (1954). A sample containing specimens of *A. abscissa* from Reuss' material collected around Atzgersdorf was chosen by Turnovsky and deposited at the Natural History Museum Vienna (Geological–Palaeontological Department) under the catalogue number 1949/III/16. The specimens are now registered as Lectotype REUSS 75 Atzgersdorf (NHMW - 2011/0158/0001-003). We present here (Fig. 2A) the Papp's drawing from Turnovsky (1954) and compare it to the chosen lectotype specimen (Fig. 2B, C). The inner view of the valve especially is illustrative of the acuminate shape of *A. abscissa* and resembles the specimens from the Reuss material sampled at Sopron (Fig. 3).

We will take this information as evidence for the definition of *A. abscissa* (Reuss), *sensu stricto*, when we will redefine (below) this species with morphometric and multivariate statistic procedures.

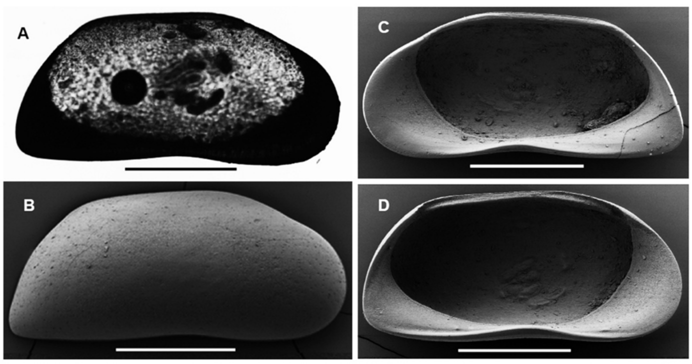

Fig. 3: Amplocypris abscissa, Reuss material from Sopron; A–C – right valve (RV), D – left valve (LV); A, B – external view, C, D internal view, A – valve ÖD 7444 in TLM view, B – valve ÖD 10Ra, SEM view, C – valve ÖD 12Ri inner view, D – valve ÖD 6; Li inner view; numbers pertain to the photos of the material deposited in the ostracod collection at the Universalmuseum Joanneum, Department of Geology and Palaeontology, Graz; scale bars = 0.5 mm.

1.5. Definition of *Amplocypris* Zalanyi, 1944 and comments on *Amplocypris recta* (Reuss, 1850)

Zalanyi (1944) created the genus *Amplocypris* (type species *A. sinuosa* Zalanyi, 1944) based mainly on the special shape of the dorsal area of the valves. Zalanyi (1959) expanded the diagnosis of *Amplocypris* mentioning that the radial pore canals on the anterior and antero-ventral side are long, present in high number and many of them are fused at the base (cf. here Fig. 8B). These latter characteristics are key diagnostic traits for this genus (cf. below).

Mehes (1907) described from Soceni (Banat, Romania) and Sopron (Hungary) a new species called *Herpetocypris strigata*. This species was later on classified by Pokorný (1952) as *Herpetocypris recta* (Reuss). The extensive studies of ostracods related to the Reuss' species by Krstić (1966, 1973) documented the validity of the genus *Amplocypris*. Species, like *A. abscissa,* do not have the characteristic traits of the genus *Herpetocypris* Brady & Norman (Herpetocypridinae Kaufmann 1900). *Amplocypris* species lack anterior septa and the inner list is undeveloped. We have to mention also that the high density of simple pores (i.e., the normal pores, cf. Meisch 2000) on the whole surface of the valves and the inflated shape of the carapace, are characteristic traits for the *Amplocypris* species. Additionally these species do not display "vacuole voids" within the calcified lamella of the valves, a characteristic of *Herpetocypris* (cf. Danielopol et al. 1986).

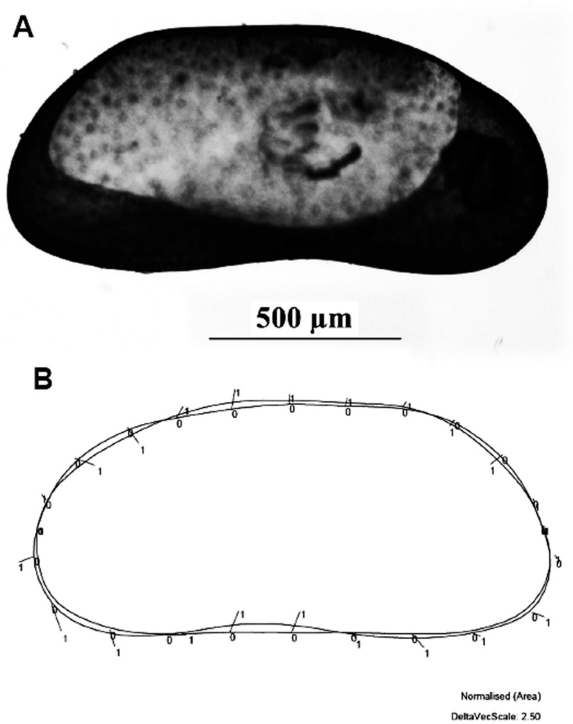

Fig. 4: Amplocypris recta, right valve; A – specimen SM16 - 3471, St. Margarethen; B – superimposition of *Amplocypris* outlines for RV (reversed) normalised to equal surface; 0 – outline of the original *A. recta* figured by Reuss (cf. here Fig. 1D), 1 – outline of the specimen SM16 - 3471; length of vector lines 2.5 enlarged.

All these peculiar traits of *Amplocypris* point to the assignment of this genus to the Eucypridinae Bronshtein 1947 and not to the Herpetocypridinae Kaufmann 1900. *Amplocypris* appears closely related to the genus *Tonnacypris* Diebel & Pietrzeniuk, recently revised by Van Der Meeren et al. (2009) and also assigned to the Eucypridinae. Species of this latter genus (we examined *T. tonnensis* Diebel & Pietrzeniuk and the information in Van Der Meeren et al. 2009) display on the antero-ventral margin of the valves shorter radial canals with few fused branches, as compared to the valves of *Amplocypris* species.

Reuss (1850) described and illustrated (cf. here Fig. 1C, D) a species related to *Amplocypris abscissa* he called *recta*. Reuss (1850) mentioned that this latter species displays three different "varieties" that he numbered with a, b and c. Pokorný (1952), as first reviser of what it is now named *Amplocypris recta*, decided that the morphological traits of the "b variety" should be diagnostic for this taxon and the figure 11a in the Reuss' monograph (cf. here Fig. 1D) should be considered the lectotype of *A. recta* (it was not stated where this lectotype is deposited!). Reuss (1850) pointed out that the "b variety", as compared to the "a variety", has the ratio height / length of less than 50 % and the antero- and the postero-dorsal sections are more or less angular. We identified at St. Margarethen in Burgenland (Lower Pannonian stage) valves which fit the descriptions of Reuss (1850) and of Pokorný (1952). We superimposed on the outline of Reuss' *recta* mentioned above (cf. Fig. 1D) the outline of St. Margarethen (cf. our specimen No. 3471 SM16; Annex 1, Tab. 1; Fig. 4A) and their close similarity becomes apparent (cf. here Fig. 4B). Therefore we will use here this species for comparative purposes in order to better define *Amplocypris abscissa*.

1.6. *Amplocypris abscissa* from Hennersdorf and additional comparative material

The ostracod material here discussed originates mainly from the Hennersdorf site (Fig. 5) studied by Harzhauser & Mandic (2004), Harzhauser et al. (2004, 2008). The investigated area is a clay pit about 10 km south–east from Vienna. Currently, the section is about 14 m thick and comprises blue-grey clay with *in situ* clusters of *Congeria subglobosa* Partsch in the base. This is topped by a 4 cm-thick bivalve coquina, termed He 4 in Harzhauser & Mandic (2004). This marker bed underlies an approximately 8 m-thick unit of green-blue-grey clay and silty-clay intercalated by numerous thin layers with loose dreissenid coquinas. The top of the Hennersdorf section is represented by about 7–8 m yellow-grey clay and silt which is practically barren of macrofossils except for a marker coquina bed (He 1 in Harzhauser & Mandic 2004) in its basal part. The succession is dated as Middle Pannonian and corresponds to the later stage, Pannonian E (Harzhauser et al. 2004). The magnetostratigraphic dating of the section Hennersdorf allowed its correlation with the chron C5n (Magyar et al. 1999b).

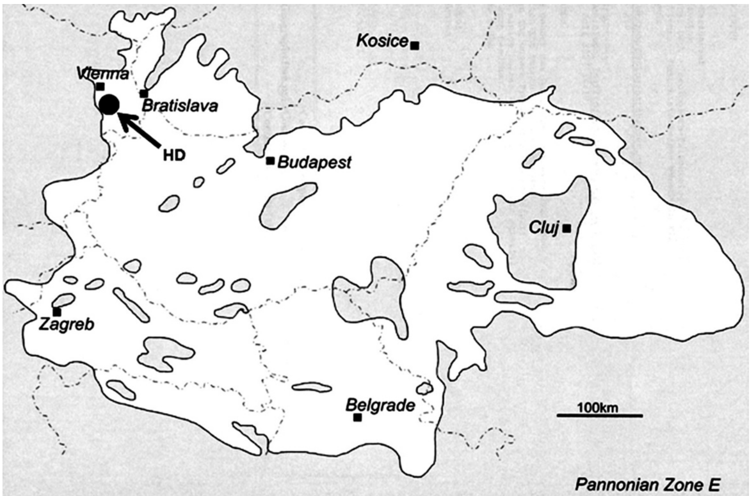

Fig. 5: Palaeogeographic reconstruction of Lake Pannon, c. 9.5 Ma BP (from Magyar et al. 1999a); HD – position of the Hennersdorf sampling site.

Our *Amplocypris* material from Hennersdorf (cf. Annex 1, Tab. 1) comes from bulk samples collected in 2006 in a series of layers, labelled in figure 6 on the left of the lithological profile. Additionally 11 short cores of 0.35 to 0.5 m length, sliced in half centimetre layers offered high resolution samples (cf. for their approximate position, Fig. 6). Especially core No. 6 (cf. Annex 1, Tab. 1) was rich in *Amplocypris* valves, both adult and juvenile specimens.

The ostracod assemblage at Hennersdorf is quantitatively dominated by *Cyprideis obesa* (Reuss) and *Hemicytheria folliculosa* (Reuss). We recognized only one species of *Amplocypris* that was initially left in open nomenclature (cf. Annex 1, Tab. 2 in Harzhauser et al. 2008). The frequency of this *Amplocypris* species (as number of valves in the various samples analysed) is low as compared to the former two mentioned species (Minati, Doctoral Thesis, in preparation).

Figures 7 and 8 display specimens which closely resemble the images of REUSS, therefore we consider that we identified *A. abscissa* (Reuss) at Hennersdorf. However, we noticed a wide range of morphologic variability, hence at the beginning we will treat this species as *A. abscissa* (*sensu lato*). Further analysis (see below) will bring more precision to this preliminary identification, and we will separate one of the morphotypes as *A. abscissa* (*sensu stricto*) and two other morphotypes remain to be assigned to other species.

The acuminate valves of *A. abscissa* from Hennersdorf display some interesting characteristics, respectively the left valve is higher and slightly more rounded than the right valve (Fig. 7), the dorsal hinge groove is enlarged in both the anterior and posterior third sections and on the ventral side two small pegs are visible (cf. Fig. 7B).

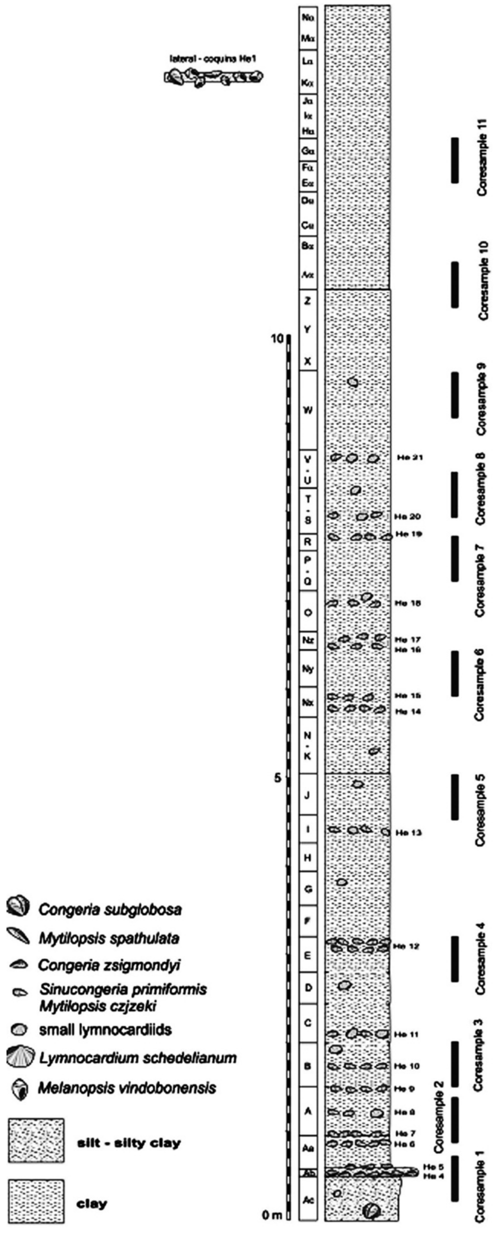

Fig. 6: Lithological profile of the Hennersdorf section (Pannonian E), from Harzhauser & Mandic (2004) on which on the left side the bulk samples are indicated and on the right side the relative position of the 11 short cores (cf. text).

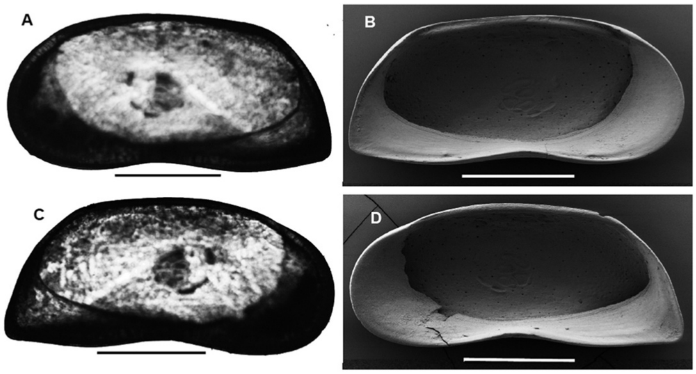

Fig. 7: Amplocypris abscissa, left (A, B) and right (C, D) valves from Hennersdorf; A, B – specimen HD 7381; C, D – specimen HD 7380; A, C –external view in TLM, B, D internal side, SEM views; scale bars = 0.5 mm.

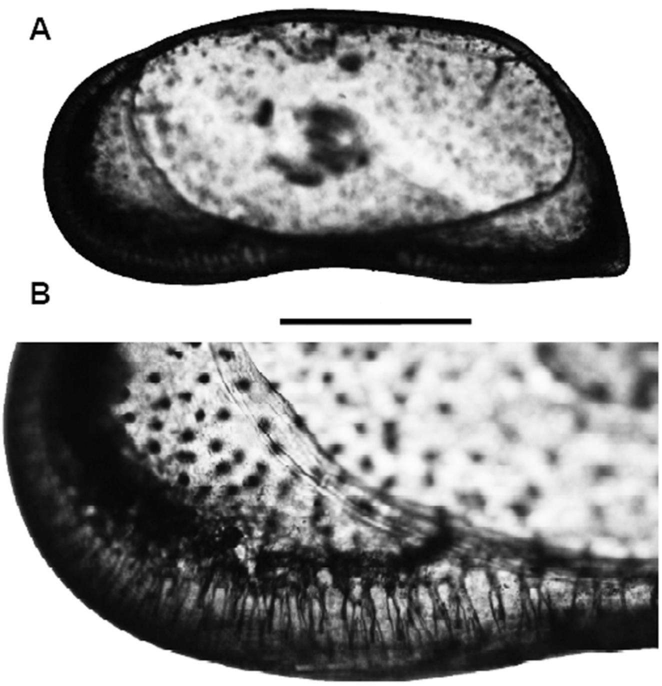

Fig. 8: Amplocypris abscissa, from Hennersdorf, TLM view (reversed position of specimen HD 7316); A – right valve (scale bar = 0.5 mm); B – the antero-ventral side showing radial canals (see text), detail from A.

The valves display large anterior and posterior vestibula (cf. Fig. 8A). On the anterior and antero-ventral side one notices (Fig. 8B) dense ramified radial canals and on the whole surface wall a large number of normal pores exist. The posterior vestibule is larger (Fig. 8A) than those of *Amplocypris recta* (Fig. 4A).

R. PIPÍK (Banská Bystrica) offered photographs of valves which he sampled at Sopron in 2008. The Sopron sections are dated as Pannonian E stage (MAGYAR et al. 1999b). A right valve of *Amplocypris abscissa* offered by PIPÌK will be compared with our material (see below).

Specimens of *Amplocypris recta* used here were sampled at St. Margarethen in Burgenland at the outcrop "Altes Zollhaus" in the layer 16 dated as Lower Pannonian (cf. Annex 1, Tab. 1; HARZHAUSER et al. 2002; BUTTINGER 2008). Additional *Amplocypris* material for this study comes from Soceni (Banat, Romania), an outcrop in the Turislav valley sampled during 2006 (cf. Annex 1, Tab. 1; DANIELOPOL et al. 2009). R. OLTEANU provided to one of us (D.L.D.) *Amplocypris* material from outcrops at the localities Groşi and Sinteşti (both in Banat, north from Soceni) dated as Early–Middle Pannonian age (OLTEANU 1971, 1986). Finally we used for this project also published figures from various authors, especially from REUSS (1850), ZALANYI (1944), POKORNÝ (1952), OLTEANU (1971) and KRSTIĆ (1973).

The material presented here is stored at the Universalmuseum Joanneum, Department of Geology & Palaeontology, Graz. The lectotype of *A. abscissa* is deposited at the Natural History Museum Vienna, Geological–Palaeontological Department.

2. Morphometric approaches for *Amplocypris abscissa*

2.1. Combining geometric with traditional morphometric techniques for comparative morphology and systematics

In recent years we have assisted in the development of techniques using multivariate statistics to the quantitative description of biological shapes. Reviews of the rapid development of this research direction were published *inter alia* by ROHLF (1990), BOOKSTEIN (1991, 1993), RICHTSMEIER et al. (1992, 2002), MACLEOD (1999, 2002), ZELDITCH et al. (2004), ADAMS et al. (2004), SHEETS et al. (2006), MITTEROECKER & GUNZ (2009), STRAUSS (2010). Specific to ostracod research we have to mention the contributions of several distinguished specialists like R.L. KAESLER, R.H. BENSON, R.A. REYMENT and A. BALTANÀS. Some of their results are presented in BENSON et al. (1982), FOSTER & KAESLER (1988), REYMENT (1985), BALTANÀS & GEIGER (1998), BALTANÀS et al. (2003), BALTANÀS (2008). The recent progress in ostracod research was achieved inter alia by the application of geometric morphometrics to the description of morphological diversity (disparity) of valves belonging to various species. We will mention the classic paper of Reyment & Bookstein (1993) and more recent contributions of Baltanàs et al. (2000), Elewa (2004), Iepure et al. (2007), Minati et al. (2008), Danielopol et al. (2008), Gross et al. (2008). Further information is presented in Baltanàs & Danielopol (2011).

For the systematics of poorly ornamented ostracods geometric morphometric techniques are not generally used despite the fact that algorithms for other groups were developed (cf. Macleod 1999; Zelditch et al. 2004; Sheets et al. 2006; Van Bocxlaer & Schultheiss 2010). In the present contribution we propose a composite method based on the algorithms existing in the computer packages MORPHOMATICA 1.6 (cf. Linhart et al. 2007; Brauneis et al. 2008; Neubauer & Linhart 2008) and PRIMER v6 combined with PERMANOVA+ for PRIMER (Clarke & Gorley 2006; Anderson et al. 2008) which should help the classification of morphotypes and further the improvement of systematics of various ostracod groups.

2.2. Choice of variables and their analysis with multivariate statistics

In a first step we use geometric morphometrics for outlines, based on the Linhart's B-spline approach in the computer programme MORPHOMATICA 1.6 (cf. the web site "Methods in Ostracodology" at http://palstrat.uni-graz.at).

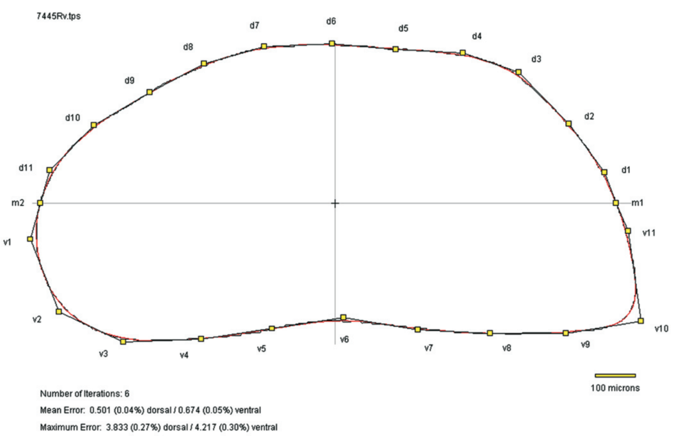

Fig. 9: Reconstruction of the outline of an *Amplocypris abscissa* valve (cf. right valve reversed of specimen ÖD 7445) using the Linhart's B-spline algorithm; symbols mark the position of the control points; the cross of the orthogonal axis of inertia marks the position of the centre of gravity; the precision for the fit of the reconstructed line (in red) to the original digitised outline (in black) is left indicated.

We produce in the Specimen module an outline based on 12 Control Points (CP) for half of the outline, (respectively, 24 CP for the whole outline) offering a very good fit to the original digitised outline (cf. Fig. 9). The position of these CP will be further used as reference directions for the vectors which will be chosen as morphological traits (see further details and Fig. 13).

We superimposed, in MORPHOMATICA, with the Cluster module and the standardised option (i.e. normalised for area), the digitised outline of Reuss' figure (cf. here Fig. 1B) and those of the Hennersdorf specimen No. HD 7316 (cf. Fig. 8A). One should note in figure 10 the close fit between both valves. This is well displayed not only by the differences in the area deviation of the two superimposed valves but also expressed by the short length of the vectors.

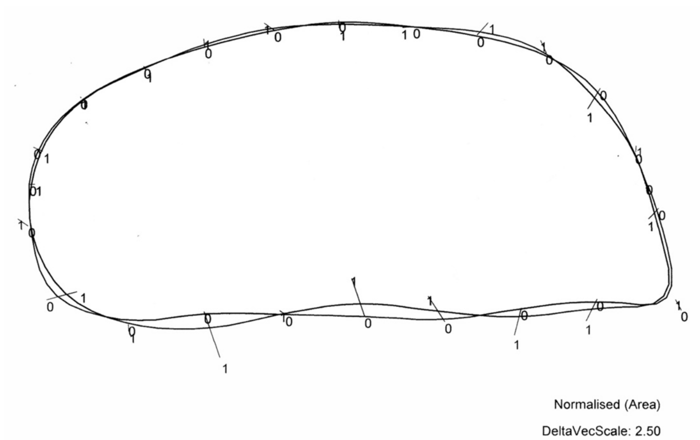

Fig. 10: Amplocypris abscissa, superimposition of outlines for right valves (reversed) standardised for equal surface; 0 – outline of the original Reuss figure (cf. our Fig. 1 B), 1 – outline of the Hennersdorf specimen No. HD 7316 (cf. Fig. 8A); differences in shape expressed through the length of the delta vectors (2.5 x enlarged).

We continued with the analysis of the outlines of *Amplocypris* material using the non-standardised approach in MORPHOMATICA. We noticed in the Hennersdorf material of *Amplocypris* that the form of the valves (i.e., their shape and their size) is polymorphic. Figure 11 displays such polymorphism. We compared the form of *Amplocypris recta* (Fig. 11A), used as a reference shape with those of several representative specimens from Hennersdorf (Fig. 11B–F). By superimposition of these outlines (Fig. 12) the differences in size and shape are clearly visible and can be spatially approximated through the dimension of the vectors at the various control points. One should note on figure 12 the postero-ventral differences around the CP v10 (see also for the location of this control point, Fig. 9). This approach is qualitatively informative during an exploratory analysis but we decided not to use it for further analyses because in cases where the vectors are orientated more-or-less parallel to the outline they do not express true differences between shapes. The problem is explained in NEUBAUER (2008) and in NEUBAUER & LINHART (2008). An additional difficulty arises with the necessary usage of a reference outline that cannot be *a priori* stated for general purposes.

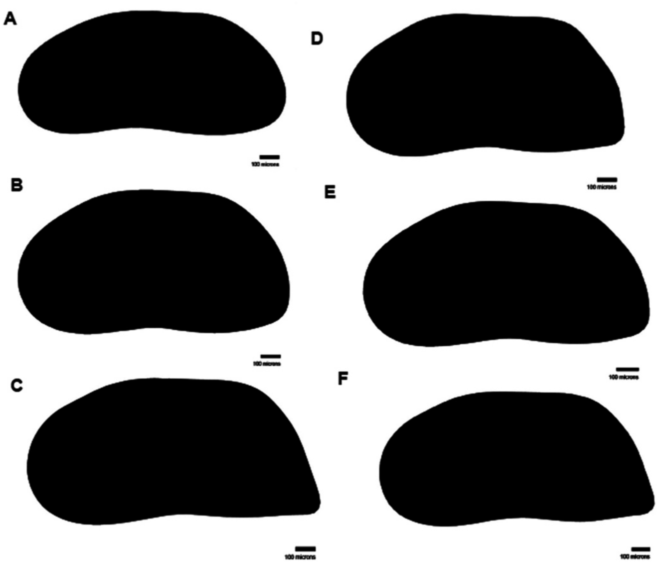

Fig. 11: Right valves of *Amplocypris* species (reversed view), diversity of shapes; A – *A. recta*, specimen SM16 - 3471; B to F – valves of *A. abscissa*; B - HD 3829, C - HD 7354, D - HD 7373, E - HD 7942, F - HD 7356; scale bars = 0.1 mm.

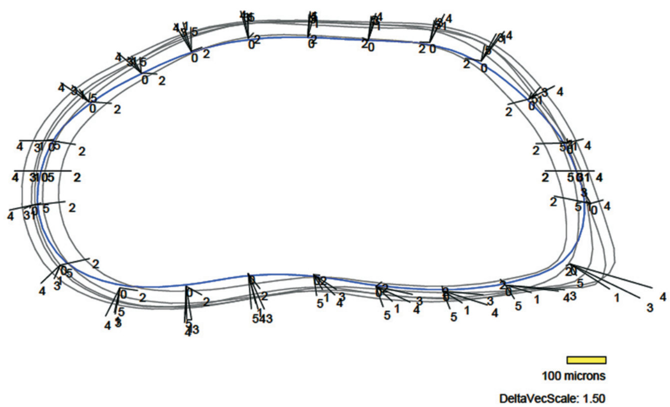

Fig. 12: Right valves of *Amplocypris* species (reversed view); superimposition of outlines for right valves showing at 12 control points differences in shape expressed as the size of the delta vectors (1.5 x enlarged); 0 – outline of the reference shape, *A. recta*, specimen SM16 - 3471, 1- 5 outlines of *A. abscissa*, specimens B–F in Fig. 11.

We decided in a first approach to use variables measured on a linear scale in millimetre units. The traits chosen as variables were defined after we standardised for length the outline in MORPHOMATICA (see details on the procedure used below). Figure 13 shows the seven linear variables we chose for an exploratory analysis. They were coded as follows: H – the maximal height of the outline measured on the y axis of the boundingbox. Cv10 – the distance between the Centre of gravity C (cf. for its definition Neubauer & Linhart 2008) and the margin of the digitised outline, using the direction of the CP v10. The other variables are defined like the Cv10 and they are named Cm1, Cd2, Cd9, Cm2 and Cv2 (cf. Fig. 13).

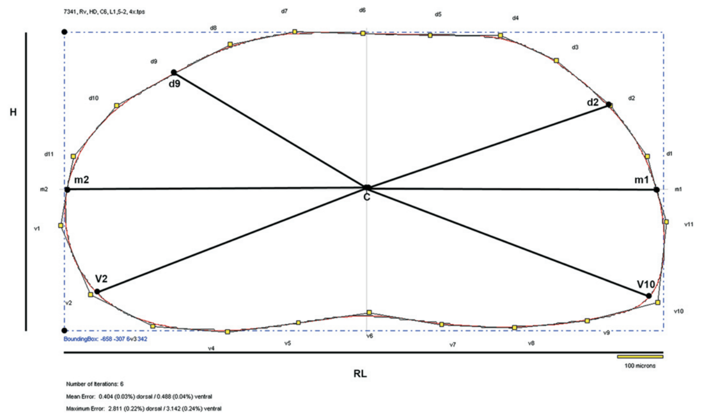

Fig. 13: Diagrammatic representation of an *Amplocypris* right valve (reversed view) inserted within a bounding box standardised for a length of 200 mm (RL = relative length); the vectors used as linear variables are: H – maximal height. Cv10 – the length (in mm) from the centre of gravity (C) to the outline on the direction of the v10 control point. Similarly to Cv10 are defined also the vectors Cm1, Cd2, Cd9, Cm2, Cv2. all measurements are done with the "tps.Dig" programme for landmarks and saved as M-variables in an additional tps file (see text).

The seven chosen variables are measured on the MORPHOMATICA figure using the procedures implemented in the programme tps.Dig (Rohlf 2003). This is explained in the following paragraph.

From the MORPHOMATICA, Specimen module, we use the approximated outline obtained with 12 CP. We open in Specimen, Properties and activate in Graphics, Draw bounding box. We move with the mouse the left bar of the MORPHOMATICA-screen (which separates the outline image from the left side where specimen information is listed) to the right side in order to set the size of the X axis length of the bounding box to 200 mm. Further in the Specimen module we activate Export (the figure) to image (file). This latter action will save the standardised image in a bmp-file. We open the programme tps.Dig, Import source/File open (bmp-file). We continue in the Digitise landmarks mode and we fix the landmarks (cf. the black points in Fig. 13), continue setting the scale, i.e., we use in Options command Set scale fixing to 200 (the length of the X axis of the bounding box). We continue activating the key “Make linear measurements” (the comb key on the screen) and the measured lengths are transferred further with the activated right mouse key “Add as variable” in a tps-file. At the end the variables labelled M1-M7 are saved in a tps-file. This latter will be open and the data transferred in an EXCEL file with variables as columns and samples as rows (cf. Annex 1, Tab. 2). The EXCEL matrix is transferred in PRIMER+ PERMANOVA and with multivariate statistics further analysed (see below). We open in PRIMER, Sample data (samples as rows), continue with Sample matrix, activate Resemblance routine and we chose Euclidean distance. On the obtained pairwise resemblance matrix we open in Analyse the cluster programme Group average (which classifies hierarchically dissimilarities as unweighted pair-groups on arithmetic averages, the so-called UPGMA method).

We use first the data set from Hennersdorf, represented by 89 sampling units for the cluster analysis, without any prior assumption of their degree of similarities. Figure 14 shows the results expressed as a dendrogram where the Y axis shows the degree of dissimilarity of the clusters formed by the groups of sampling units.

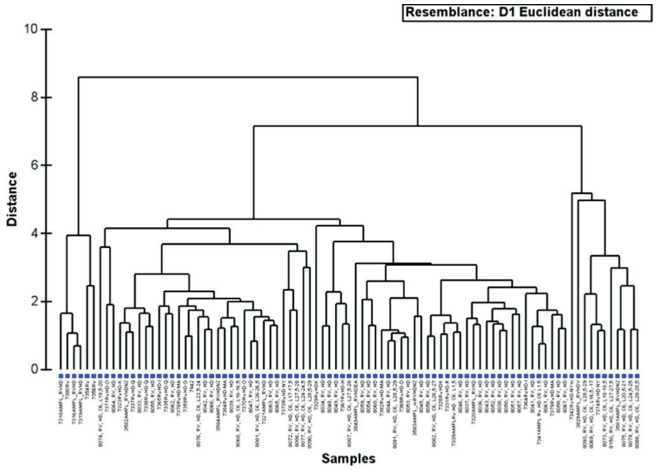

Fig. 14: Dendrogram relating the 89 right valves of *A. abscissa* from Hennersdorf using the group-average algorithm on Euclidean distances of the seven linear variables.

We select the three primary clusters and we look again in MORPHOMATICA at the outline shapes. The first group contains elements related to what we identified as *abscissa* morphotype. The next large group splits in two subgroups. The left-side cluster is the most abundant and covers many round-shaped outlines while the right-side cluster contains more or less rectangular shapes. We named those two clusters *rotunda* and *quasi-abscissa* morphotype-groups respectively. Figure 15 therefore proposes a first classification using the UPGMA method that we explore further through the Principal

Coordinates analysis or PCO (Fig. 16). In this latter diagram one sees that the first two axis of the PCO explain 88.4 % of the total variation (for the rationale of the PCO routine, cf. ANDERSON et al. 2008).

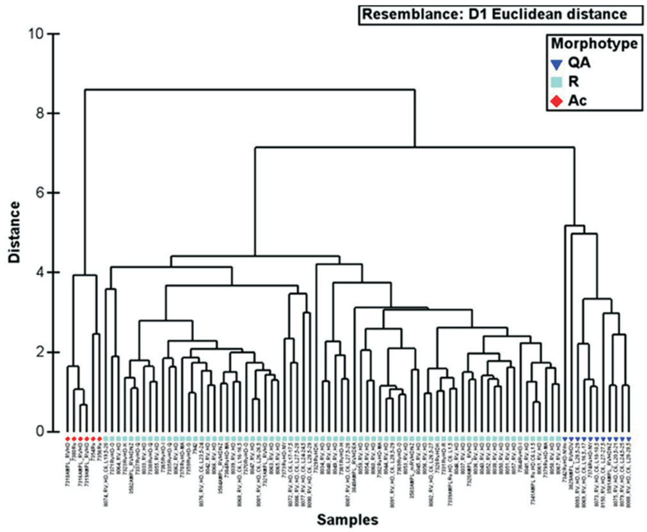

Fig. 15: Dendrogram of the 89 Hennersdorf right valves of *A. abscissa* using the group-average algorithm on Euclidean distances as in Fig. 14 but with the three main clusters defined as *abscissa* (Ac), *quasi-abscissa* (QA) and *rotunda* (R).

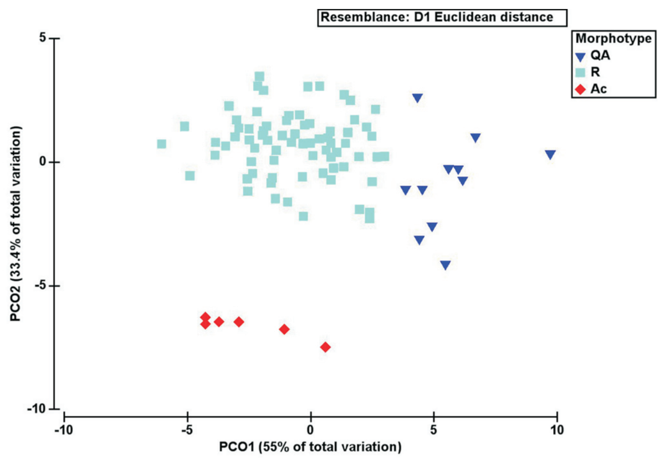

Fig. 16: Principal Coordinate Ordination (PCO) of 89 right valves of *A. abscissa* from Hennersdorf, grouped in three classes, *abscissa* (Ac), *quasi-abscissa* (QA) and *rotunda* (R) (cf. also Fig. 15).

We need now to confirm the preliminary classification through additional analyses. We replicate the data adding the variables measured on the outlines of the right valves of Reuss (Fig. 1 B), of Papp-Turnovsky (Fig. 2A) and of the lectotype of *A. abscissa* (Fig. 2C), the reference valve from St. Margarethen identified as *Amplocypris recta*, on six *Amplocypris* outlines of the original material of Reuss from Sopron and of the two outlines from Soceni from the Turislav valley (layer 5). The data are presented in Annex 1, Table 2. We further proceed with UPGMA-cluster and PCO analyses on 101 sample units. Figures 17 and 18 display the results.

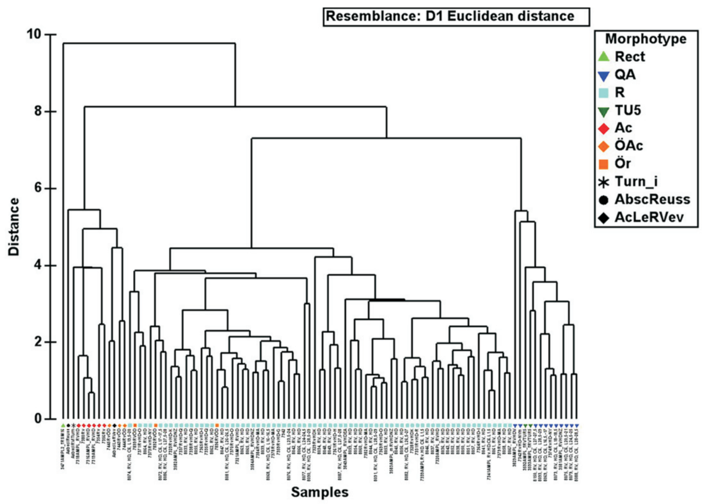

Fig. 17: Dendrogram using the group-average algorithm on Euclidean distances of 101 right valves belonging to *A. abscissa* from Hennersdorf (specimens labelled Ac, QA, R), from Sopron (labelled ÖAc and Ör), Soceni-Turislav valley, layer 5 (TU5), the Reuss original *abscissa* figure (AbscReuss, cf. Fig. 1B), the Papp-Turnovsky 's inner view figure (Turn_i, cf. Fig. 2 A), the *A. abscissa* lectotype (AcLeRVev, cf. Fig. 2C) as well as *Amplocypris* recta from St. Margarethen (Rect, cf. Fig. 4A).

Amplocypris recta appears the most derived item while the valves figured by Reuss, Papp-Turnovsky and the Atzgersdorf lectotype cluster with the *abscissa*-valves of Hennersdorf and three valves from the Reuss sample. Three other valves of the Reuss' material cluster with the *rotunda* group. The two valves of Turislav valley are classified as *quasi-abscissa* shape. Therefore the three morphotype-categories are confirmed and we now continue with another series of analyses comparing these three main morphotypes. We use only 98 samples (i.e., we left out the St. Margarethen, the lectotype, the Reuss and the Papp-Turnovsky outlines) and we proceed with a CAP, or Canonical Analysis of Principal Coordinates (for the rationale and the procedure of this routine, cf. Anderson et al. 2008). Figure 19 displays the data on the two axes of the CAP. This latter analysis and especially a permutation test using only those two axes offers us information on how well the samples were classified.

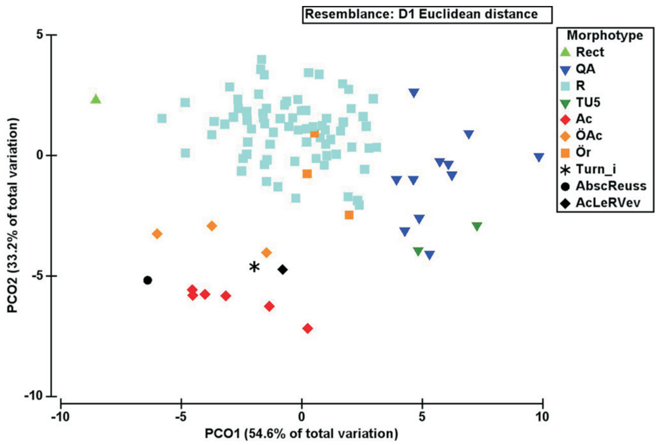

Fig. 18: Principal Coordinate Ordination (PCO) of the valves of *Amplocypris* used for the Cluster Analysis displayed in Fig. 17 grouped in the main morphotype classes. The positions of the Reuss, Papp-Turnovsky and the *A. abscissa* lectotype valves are added (symbols as in Fig. 17).

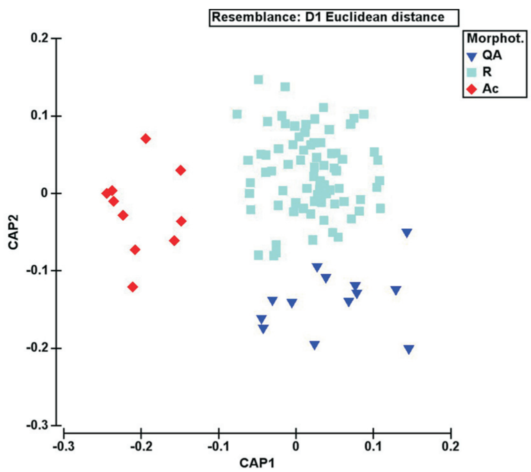

Fig. 19: Canonical Ordination of Principal Coordinates (CAP) of 98 valves of *A. abscissa* grouped within the three main morphotypes *abscissa* (Ac), *quasi-abscissa* (QA) and *rotunda* (R); not used are the data for the variables of *Amplocypris recta* and those for *A. abscissa* related to Reuss and Papp-Turnovsky outlines.

The total percentage of correct classified valves is 93.81 %, respectively only six valves from 98 were misclassified. They are: HD 7373, ÖD 7892, HD 8072, HD 8077, HD 8086 and HD 8090. The value of the trace statistics for the permutation test is 1.216 and that of the first squared canonical correlation is 0.67; in both cases the location of the centroids (or means) of the three groups are significantly different

(P = 0.001). The misclassified shapes all originate from the *rotunda* group (6 from 75 samples) while the other two groups were found as 100 % well sorted. We accept the suggestion of the randomised test to change the position of the six misclassified items from the *rotunda* category to the *quasi-abscissa*. However, the present results do not answer one of the main questions of our project, namely if using quantitative methods one is able to objectively differentiate the polymorphic populations of the so-called taxon *Amplocypris abscissa* (*sensu lato*), especially the samples identified as *rotunda* and *quasi-abscissa*. Therefore we continue with the search for additional variables (see below).

2.3. The composite morphometric approach

The term composite is used here to indicate that we combine the data of variables (the previous seven ones and two additional ones) obtained from measurements on different scales, respectively on an interval scale with linear and angular values and a ratio scale. Below, we present two new variables which can be accurately evaluated. Figure 20 shows how one can measure using a graphic computer programme (e.g., we used ADOBE-PHOTOSHOP) the ratio between "h", the lower height section (starting from the bottom to the tangential point of the posterior outline section) and "H", the maximum height of the valve.

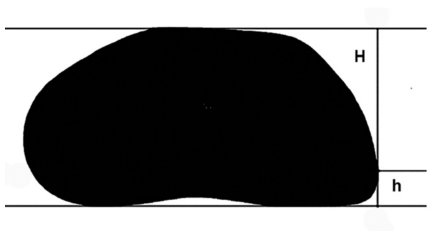

Fig. 20: The pi index (h/H); h – height to the posterior tangential point, H – maximum height (cf. text).

We called this variable the "pi index" and expressed it as ratio in percentage. The next variable that we found useful is the angle formed by the lines relating the control point v10 to the adjacent ones (cf. Fig. 9). We measured it on the bounding-box figures standardised to a given length (i.e., to 200 mm length). The couple of variables Cv10, pi and angle v10 describe in a very useful way the shape of the distal section of the postero-ventral part of the outline (cf. Annex 1, Tab. 1–2). We measured the pi and the angle v10 on the 97 *Amplocypris* valves and continued the multivariate analysis using 9 variables, using PRIMER algorithms. For this purpose it is necessary to normalise the data; this means the values measured on different scales have to be brought to a comparable scale (Clarke & Gorley 2006). The normalisation procedure applies to PERMANOVA algorithms too (Anderson et al. 2008).

We next create in PRIMER a new matrix with nine columns (the variables) and 97 rows (the valves as sample units) that we further normalise by activating in the module "analyse-pretreatment" as mentioned above. We continue and transform this latter matrix in a new resemblance matrix, i.e., a pairwise Euclidean distance of dissimilarities. This latter will be used for further exploratory and confirmatory analyses of the morphometric data.

In the previous section the results of the CAP analysis pointed out six valves which were misclassified. As suggested by the CAP-results we changed their position from the *rotunda* to the *quasi-abscissa* group. With the new resemblance matrix we perform a CAP analysis (Fig. 21).

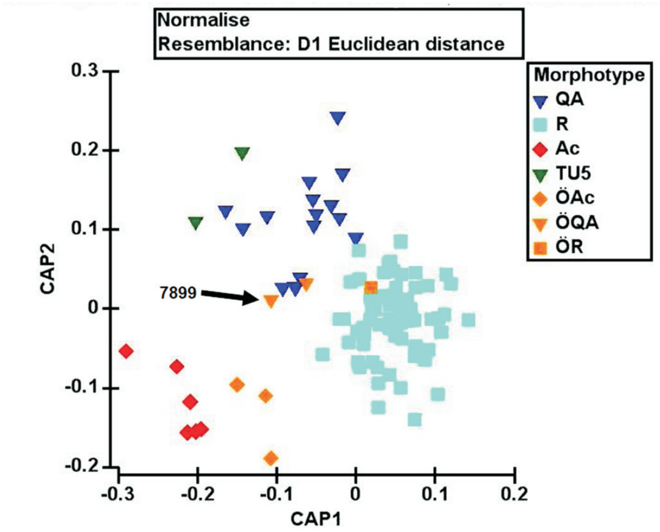

Fig. 21: Canonical Ordination of Principal Coordinates (CAP) of the 97 valves of *Amplocypris* produced with nine variables of the right valves belonging to *A. abscissa* from Hennersdorf (labelled Ac, QA, R), from Sopron (ÖAc and Ör), Soceni-Turislav valley, layer 5 (TU5). To the seven scalar variables already used (cf. Tab. 2) were added the values of the angle of the control point v10 (Ang v10) as well as the pi index (cf. Tab. 3 and text). Note the position of sample ÖD 7899 from Sopron now evaluated as a *quasi-abscissa* morphotype and the Soceni samples located at the periphery of the sampling cloud *quasi-abscissa*.

This shows that the three main groups are largely preserved with one additional change the valve ÖD 7899 (cf. Fig. 24D) moved from *rotunda* to the *quasi-abscissa* group. This appears to be a consequence of the role played by the new variables which better characterise the postero-ventral section of the outline, respectively the margin is slightly straighter and angular than most *rotunda* specimens. The previous data set was further analysed with the PCO-procedure, using this time only three categories, the *abscissa*, *rotunda* and *quasi-abscissa* morphotypes (Fig. 22).

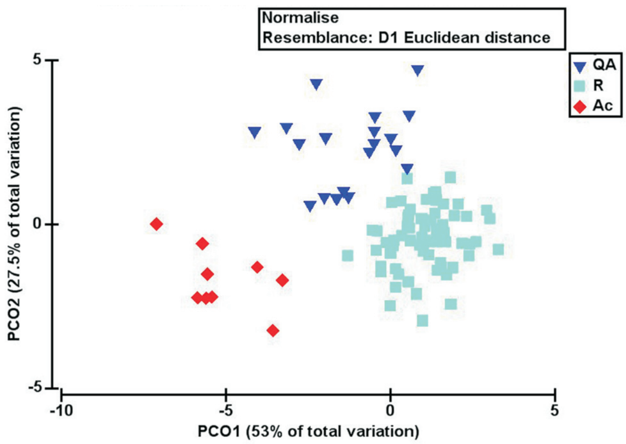

Fig. 22: Principal Coordinate Ordination (PCO) of the 97 valves of *Amplocypris* used for the PCO with 9 variables (cf. Fig. 21), grouped within three main morphotypes *abscissa* (Ac), *quasi-abscissa* (QA) and *rotunda* (R).

The first two axes explain 80.5 % of the variability. The *abscissa* cloud of points is well separated from the two other groups. For these latter groups one notices a poorer delineation. However, even here we suspect a statistically significant separation between the centroids of the sample groups. See Anderson et al. (2008) for the way the centroid of the dispersion of the sampling points in a 2D-morphospace is calculated using as a measure of resemblance the D1 Euclidean distance.

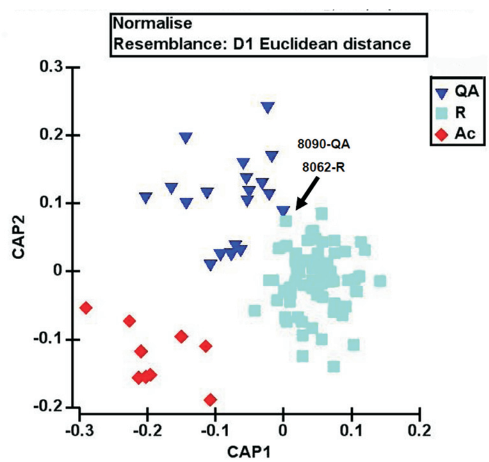

Fig. 23: Canonical Ordination of Principal Coordinates (CAP) for the data of the PCO analysis displayed in Fig. 22. Note the close position of the two valves 8090-QA and 8062-R, this latter considered misclassified (cf. text).

Therefore we continue with a confirmatory CAP analysis (Fig. 23) using the first two axes (m - 2) like in the PCO. The first squared canonical correlation axis of the CAP represents 0.78 while the 2nd one 0.60. The leave-one-out allocation of observations to groups for the choice of m - 2 shows 100 % correct classification of the samples in the groups *abscissa*, and *quasi-abscissa* and 98.53 % in the *rotunda* group, and in the latter from 67 valves only one item (the HD 8062 valve – on Fig 23 given as 8062 and 8062-R) was considered misclassified. The output of this analysis suggests moving this item (HD 8062) from the *rotunda* to the *quasi-abscissa* group. The results of a permutation test in CAP shows that the position of the centroids of the three clouds of sample points in the morphospace are significantly separated ($P = 0.001$). The trace statistics value is 1.382 (cf. information for the interest of this statistics Anderson et al. 2008).

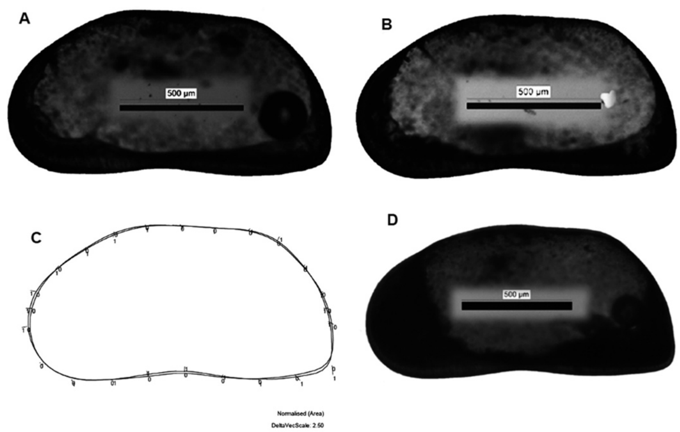

Fig. 24: Shape differences between the reversed right valves HD 8090 (A) and HD 8062 (B); C – superimposition in the standardised for surface modus of the outlines HD 8062 (1) on the outline HD 8090 (0); D – the right valve ÖD 7899 (reversed view).

The shape differences between the valves HD 8062 and HD 8090 were further examined. Their close morphological similarity appears by comparing the figures 24 A and B and by the geometric superimposition of their outlines using the standardised sub-routine of MORPHOMATICA (cf. Fig 24C).

We were interested to see if we added a new variable we could attain a 100 % success in the statistical separation of the three morphotypes *abscissa*, *rotunda* and *quasi-abscissa*. Generally, for the standard description of ostracod taxa one uses also the length of adult valves. Therefore we added length to the 9 variables which characterise the valve shape (cf. Annex 1, Table 3). We now compare the "form" of the *Amplocypris abscissa* (*sensu lato*) using 10 variables. We proceeded with a new CAP for these10 variables using only two axes (m - 2). Figure 25 shows that the valves HD 8062 and HD 8090 previously poorly discriminated are now well separated.

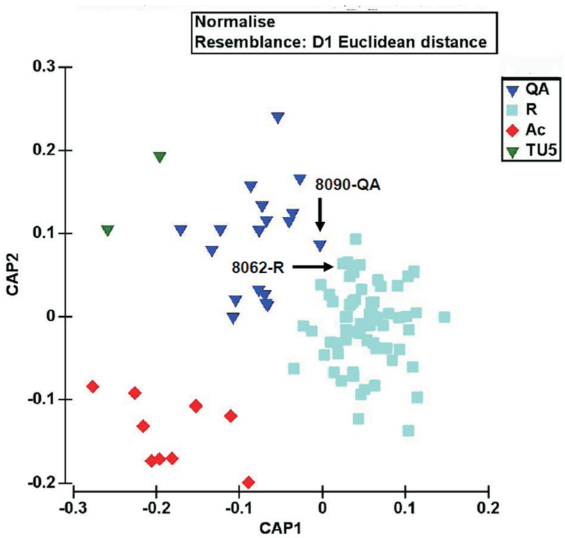

Fig. 25: Canonical Ordination of Principal Coordinates (CAP) of *A. abscissa* for the data set of 97 sampling units, grouped within the main morphotypes, *abscissa* (Ac), *quasi-abscissa* (QA) and *rotunda* (R) and 10 variables; the Turislav valves (TU5) are showed separately (cf. text). Note the special position in the morphospace of the samples HD 8062 and HD 8090.

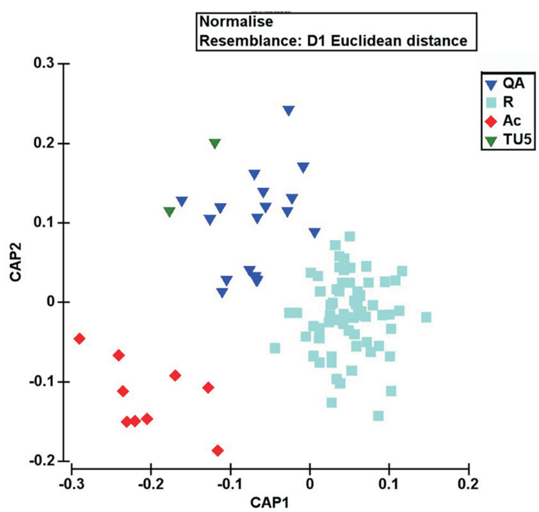

Fig. 26: Canonical Ordination of Principal Coordinates (CAP) of *A. abscissa* for the data set of 97 sampling units, grouped within the main morphotypes, *abscissa* (Ac), *quasi-abscissa* (QA) and *rotunda* (R) and 10 variables; the position of the Turislav valves (TU5) in the morphospace is due to the simulated length variable (cf. text).

This is explained by the length difference between the two valves (cf. Annex 1, Table 3), respectively 1.33 mm for HD 8090 and 1.18 mm length in the case of HD 8062. We noticed also that because the size of the two Turislav valves are very large, respectively 1.78 and 1.67 mm length (cf. Annex 1, Tab. 3), their position moved in the morphological space (cf. Fig. 25) to the left side.

In order to confirm the importance of size for the position of the valves in the morphological space we simulated the values of the Turislav valves reducing their length to 1.4 mm and 1.3 mm. Figure 26 shows that Turislav items (green) are now placed closer to the Hennersdorf valves (blue). The importance of this variable for the separation of the three groups of morphotypes is clear also when one uses the SIMPER routine in PRIMER. This latter procedure calculates the contribution of the variables to the similarity degree of the investigated groups (Clarke & Warwick 2001; Clarke & Gorley 2006). This type of exercise, done also with simulation for other traits, allows us to better understand the contribution of a given variable to the morphological separation of the morphotypes in a multidimensional space.

In the following, we show an example of simulation which helps to understand the separation between morphotypes using the variable Cv10. We took the outline of the valve HD 7354 which belongs to *abscissa* morphotype and we compared it with *rotunda*-shape valve HD 7370 (Fig. 27A–B).

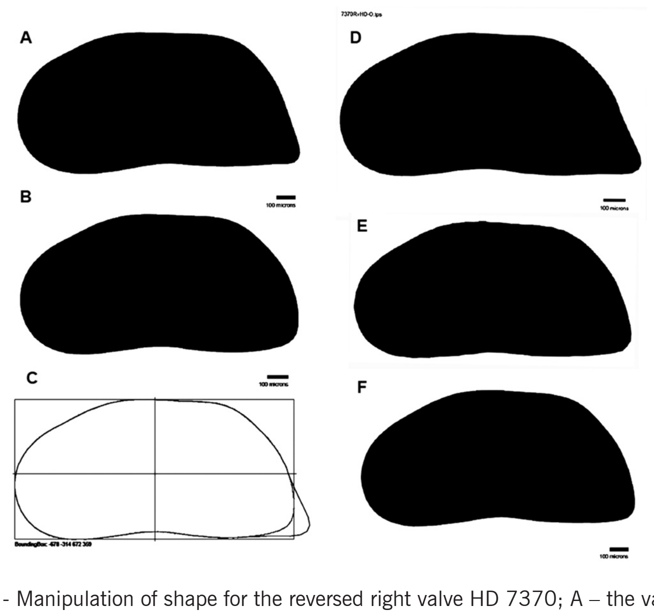

Fig. 27: A–D - Manipulation of shape for the reversed right valve HD 7370; A – the valve HD 7354 *abscissa*-type; B – the valve HD 7370 *rotunda*-type; C – the change of outline shape of HD 7370 through the simulated Cv10 vector's length (cf. text); D – the new virtual HD 7370 as *abscissa*-type; E–F – right valves from Sopron (reversed view); E – specimen Pip_ÖD offered by R. Pipík; F – specimen ÖD 7445, coll. A.E. Reuss.

The vector Cv10 of the former valve is longer than of the *rotunda* one (cf. Annex 1, Tab. 2). We approximated in MORPHOMATICA their outlines using the command for 12 control points on the dorsal, respectively ventral side. Further, we changed the coordinates of the control point v10 of the valve HD 7370 with those of HD 7354 activating the key for interactive play with the control point coordinates (cf. Brauneis et al. 2008). The result of this simulation is in Fig. 27 C. The new outline was further processed with the tps.Dig and MORPHOMATICA programmes and we got a new virtual valve (Fig. 27D). This latter was further inserted into our data matrix for 9 variables and submitted to a PCO analysis. The results are in Fig. 28, pointing out the important role of the variable Cv10 for the characterisation of *Amplocypris* outlines.

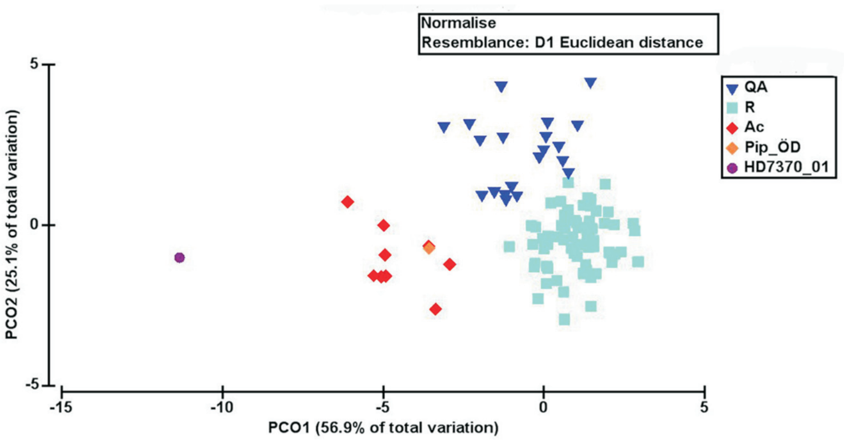

Fig. 28: Principal Coordinate Ordination (PCO) using 9 variables for the 97 valves of *Amplocypris* used in Fig. 22, the Pipík specimen (Pip_ÖD) and the virtual *abscissa*-type HD 7370_01.

In order to verify the value of our new method to describe morphotypes with the algorithms offered here we considered it necessary to replicate our data. Here we show (cf. Fig. 28) that a right valve of *Amplocypris abscissa* from Sopron sampled in 2008 by R. Pipìk (Pip_ÖD in Fig. 27E), because of its similar shape with the Reuss' item ÖD 7445 (Fig. 27F), when inserted in our data matrix for 9 variables and further analysed with the PCO algorithm, both occupy the same position in the morphological space. Note that the Reuss' valve was assigned to the *abscissa* morphotype. Through superimposition of the two outlines obtained with the standardising for surface routine in MORPHOMATICA (Fig. 29) one can see again their close shape resemblance. We conclude that this new approach for morphological characterisation of valves with few visible character traits offers meaningful results. It gives us the impetus to continue our project in order to define the morphotypes as categorical entities.

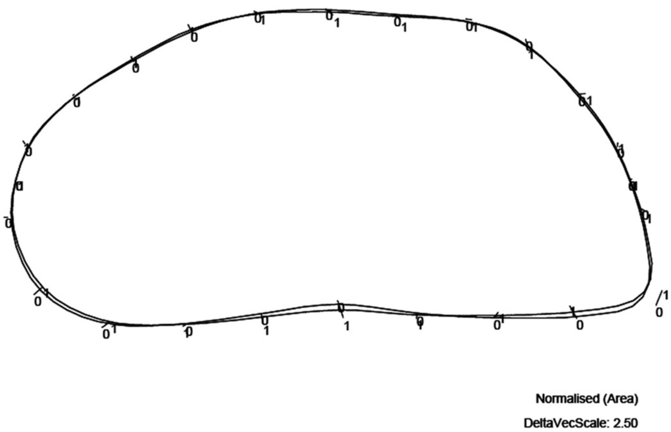

Fig. 29: Superimposition in standardised for surface mode of the Sopron valves ÖD 7445, REUSS' material (0) and PIPÌK's specimen Pip_ÖD (1).

3. Diagnosis of morphotype profiles and possible applications of the morphometric approach to the systematics of the genus *Amplocypris*

In the previous sections we differentiated with multivariate statistical procedures within *Amplocypris abscissa* (*sensu lato*) three morphotypes that we named *abscissa*, *quasi-abscissa* and *rotunda*. If one intends to use these categorical entities for the systematics of *Amplocypris* than diagnoses are required as stated in Article 13.1 of the International Code of Zoological Nomenclature (ICZN 2000). A diagnosis following this Code is "*a statement in words that purports to give those characters which differentiate the taxon from other taxa which is likely to be confused*" (ICZN 2000: 103).

In the following we propose differential diagnoses using information in Table 4 (Annex 1) and in the figures accompanying this text. Table 4 shows that the three morphotypes are characterised as groups by their arithmetic mean with the 99 % confidence limits i (± CL). These latter were obtained by the bootstrap technique (which avoids parametric assumptions) implemented in the computer programme annexed to the text-book *Ecological Methodology* (KREBS 1999). The usage of confidence levels allows us to see how well the sample group is expected to reflect the population from which it came (SOKAL & ROHLF 1995). The minimum-maximum range of each variable for the three morphotypes is also mentioned in order to show that they display slightly overlapping values between populations.

For a synthetic characterization of differences between sets of multivariate data MANLY (1998) offers *inter alia* as a solution for the presentation of differential diagnoses, graphical profiles where the mean values for the various variables are linearly presented. Each taxon is represented by a specific trajectory.

In the present contribution we define each morphotype by a selection of traits with their statistical peculiarities which at the end produces a specific profile, in essence a general image which applies to the group.

Gould (1996) criticised the usage of the average value (the central tendency of a sample) when dealing with evolutionary trends. Gould considered that an average value as a statistic is a mental construct which does not occur under natural conditions. Hence, he proposed to use individual variables originating from concrete entities which characterise them directly. In the following we show that this criticism can be avoided.

We produced for each morphotype a mean virtual shape using the non-standardised command in MORPHOMATICA (Fig. 30). We also looked for each morphotype in the pairwise normalised resemblance matrix of PRIMER for the case of 9 variables (i.e., the length variable not considered) and we extracted the mean pairwise Euclidean distance relating two individuals (the procedure will be demonstrated during the Workshop MIO-2, July 2011). We noticed (see below) that the outlines of these pair items resemble closely the virtual mean outlines of these morphotypes.

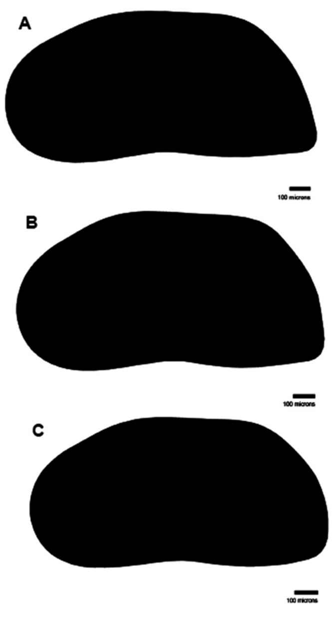

Fig. 30: The virtual mean outlines of the valves belonging to the three morphotypes of *A. abscissa*: A – *abscissa* (Ac), B – *quasi-abscissa* (QA), C – *rotunda* (R) produced with the non-standardised for surface algorithm in MORPHOMATICA.

Figure 31 show the couple of the two *quasi-abscissa* (Fig. 31A–B) and *rotunda* (Fig. 31C–D) morphotypes. Further, we superimposed the outline of one of these individuals on the mean virtual outline using the standardised command and the similarity between the shapes of simulated case and the real individual appears (cf. Fig. 32 A–C).

Therefore we consider that the profiles we will present below have an empirical meaning. Finally we consider that the diagnosis using both descriptive words and references to quantitative information of variables is a more informative and objective presentation of morphotypes or taxa than the traditional presentations in previous publications (cf. *inter alia* Krstić 1973; Jiriček 1985). In the following we will offer for the *Amplocypris* morphotypes differential diagnoses in a sequential way and for additional information on the *Amplocypris* shapes, see Annex 2.

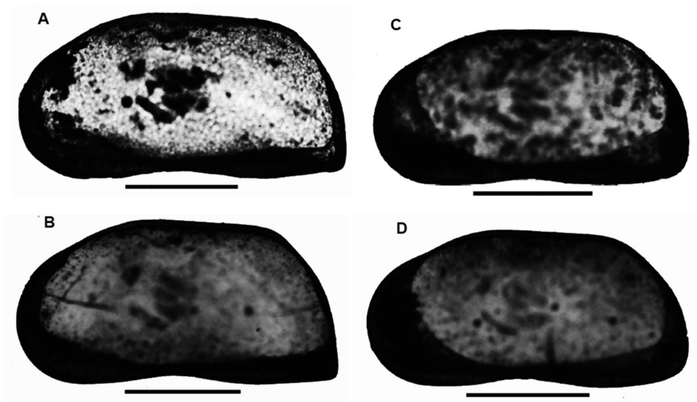

Fig. 31: The couple of the *quasi-abscissa* (A – HD 3581 and B – HD 8079) and *rotunda* valves (C – HD 8050 and D – HD 7339).

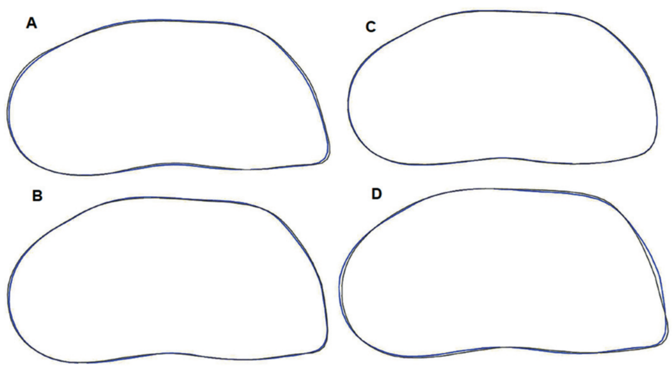

Fig. 32: A–C – Superimposition on the mean virtual shape (in blue) the outline of closely similar individuals using the standardised for surface mode in MORPHOMATICA; A – the *abscissa* mean-shape and HD 7316; B – *quasi-abscissa* mean-shape and HD 3581; C – *rotunda* mean-shape and HD 8050; D – superimposition on *quasi-abscissa* HD 3581 (blue line) of the Soceni valve TU5 - 3592.

We start with *Amplocypris recta*, which was chosen as reference system for *A. abscissa* (*sensu lato*). The right valve of *A. recta* appears flat and elongated (Fig. 4A, 11A). The standardised H value is the lowest as compared to those of *A. abscissa* (respectively 46% of the valve length; cf. Annex 1, Tab. 4); the postero-ventral outline section is essentially rounded. This wide postero-ventral curvature is well expressed through the low value of the length of the vector Cv10 and the high values of the angle V10 and the pi index (Annex 1, Tab. 4); it differs markedly from the other categories here discussed.

The morphotype *abscissa* (Figs 2, 3A–D, 7A–D, 8A, 9, 10, 11B–F, 27A, E–F, 30A, 32A; Annex 1, Tab. 4) as compared to the *quasi*-*abscissa,* can be characterised by an elongated shape with a low H value (about 48% of the length), with an oblique postero-dorsal section of the outline (reduced length of Cm1 and Cd2 vectors) and prominent acuminate postero-ventral outline (low values of the angle V10 and pi). These latter characteristics, even if more variable, are less well expressed in the group *quasi-abscissa*. Clear differences exist between the *abscissa* and the *rotunda* morphotypes when one compares the posterior shape of the outline. The latter group has higher values for Ang V10 and pi. The H value of the *rotunda* valves is slightly higher while the length is shorter than the *abscissa* morphotype.

The *quasi*-*abscissa* morphotype (Fig. 11D, 30B, 31A–B, 32B & D; Annex 1, Tab. 4) has a shape which is characterised by high values for H (more than 50% of the length), the dorso-posterior margin is generally straight and the postero-ventral section form an angle V10, frequently less than 100°. The general aspect of the shape and also the size display an intermediary position between the morphotypes *abscissa* and *rotunda*.

Finally, the *rotunda* morphotype (Fig. 11B & E, 14, 27B, 30C, 31C & D, 32C; Annex 1, Tab. 4) can be identified by its rounded anterior and posterior margins and by its smaller size (about 1.3 mm mean length of the RV).

The aim of the composite algorithm we developed was from the very beginning intended to help clarify the systematics of ostracod groups, especially where only poorly ornamented valves exist. For the *Amplocypris abscissa* case, here discussed, we are confronted with two alternatives as mentioned in the introduction: either one deals with a widely polymorphic species, which could be called *A. abscissa* (*sensu lato*) or under this latter name one can delineate several distinct taxa and in this case we consider the existence of a phylogenetic lineage within which we have a cluster of satellite species, where *A. abscissa* is one of these taxa. Because the three morphotypes are statistically delineated using multidimensional criteria, we favour this latter alternative. Our decision is based *inter alia* on the arguments of Sbordoni (1993) who points out the advantages for the degree of species separation using a composite approach. In this latter case the various types of variables are projected within a multidimensional space and analysed with multivariate statistical procedures, species are then visualised in a hyperspace. We favour the bi-dimensional space as a heuristic explanatory framework.

The morphotype *abscissa* (cf. its diagnosis) defines in our opinion the species *Amplocypris abscissa* (*sensu stricto*) with elements which already exist in the original description of Reuss (1850) as here documented. Therefore we have to ask what is the significance of the other two morphotypes? The *rotunda* form appears very similar to the shape of *A. pavlovici* Krstić, as figured in Krstić (1973). However, a clear assignment of the *rotunda* morphotype to *A. pavlovici* is uncertain for the moment as we do not have more information on the morphology and variability of this latter species.

The morphotype *quasi-abscissa* could represent another species closely related to *A. abscissa* (*sensu stricto*), taking in consideration the similarity between the shapes of the valves from Hennersdorf (on the western side of the Lake Pannon) assigned to this morphotype and the valves from Soceni (Turislav valley, layer 5) in the Romanian Banat (on the eastern side of the lake). However, we have to note that the length of the Soceni valves is more important than for those of Hennersdorf. For the moment we do not know if the large size of these valves is genetically cued or they are ecophenotypes. Therefore even if the shape of *Amplocypris* from Soceni appears to belong to the *quasi-abscissa* morphotype (cf. Fig. 32D) it is necessary to continue investigations using a larger sample size in order to test for a possible vicariant separation of *quasi-abscissa*-like populations from the western and the eastern sites of the Lake Pannon, reflecting possibly different ages and slightly different ecological conditions.

The next question one should ask is what is the palaeo-biogeographical distribution of *A. abscissa* (*sensu stricto*), as defined above? Taking into consideration information from several localities of the eastern side of Lake Pannon in the Romanian Banat (Groşi, Sinteşti and Soceni) where Olteanu (1971, 1986) mentioned *A. abscissa* and *A. recta*, we can make the following observations:

At Groşi, we identified the morphotype *rotunda* but not the morphotype *abscissa* (*sensu stricto*), as here defined. At Sinteşti, 6 km south from Groşi, we identified *Amplocypris* specimens where the right valve is much more acuminate than the *A. abscissa* from Hennersdorf. The left valves of this extremely acuminate morphotype from Sinteşti resemble the *A. abscissa* figured in Olteanu (1971). In our opinion the acuminate morphotype from Sinteşti (which occurs also at Groşi) belongs to a different *Amplocypris* species of the lineage *A. abscissa*.

At Soceni Mehes (1907) mentioned *H. strigata,* a species which Pokorný (1952) identified with *A. recta*. We also sampled at Soceni (2006) ostracods resembling *A. recta*. However, our material displays slight differences as compared to the *A. recta* from St. Margarethen, in Burgenland. Hence, it is possible that we deal with closely related species, but more material is needed to solve this open question. Additionally one should consider the exact stratigraphical occurrence of these morphotypes. Both localities, St. Margarethen and Soceni, are dated as Pannonian zone D (our data) and are thus slightly older compared to the Hennersdorf section from where no morphotypes similar to *A. recta* were detected during this project. This points to an underrated biostratigraphical value for ostracods in lake Pannon deposits.

In the case of the *abscissa*-morphotypes, here characterised, we noticed differences in their quantitative distribution and their degree of morphological disparity. At Hennersdorf, a site dated as Middle Pannonian age, the morphotype *abscissa* is rarer as compared to the *rotunda* one. K. Turnovsky in his unpublished 1949 report (quoted above) mentions that strongly acuminate individuals are more common at the sites dated as Early Pannonian than at Middle Pannonian ones. We hypothesise that the three morphotypes here identified as possible species differ not only by their morphological peculiarities but also by biological characteristics and/or ecological preferences. Therefore, the data presented here point to the idea that *A. abscissa* is a phylogenetic lineage represented by a cluster of species with more-or-less restricted geographical distributions and differentiated ecological preferences.

It is worth mentioning that the proposal to treat the morphotypes here delineated as a cluster of evolving species belonging to a phylogenetic lineage is very similar to the way Faustova et al. (2010) interpreted the sympatric morphotypes of several populations of the cladoceran group *Eubosmina* from North European lakes. In the case of the Holocene-Recent *Eubosmina* group the defined morphotypes delineated with geometric morphometric techniques represent a cluster of evolving species with apparent reproductive barriers and slightly different ecological preferences, despite their coexistence in the investigated lakes.

4. Final notes

The way one can describe and further interpret differences between ostracod valves with few visible morphological traits will certainly surprise ostracodologists. We consider that our approach, even if lengthy, is useful because the computation and interpretation, being recurrent and advancing step-by-step, make it possible to understand and verify what is done and the meaning of the output of the computation performed by the various algorithms. In this way we try to construct an objective view on the morphological differences within and among *Amplocypris abscissa* populations. This approach can be used for other projects related to the systematics, palaeoecology and/or evolution of Ostracoda, for example the mainly smooth metacopes. Our data here presented are accessible for critical review and can be improved at any time, this reflecting our philosophical view of what Objectivity is and how it should be further used.

We already have ideas about how to advance the refinement of *Amplocypris* discrimination of morphotypes and/or taxa. It is necessary to describe the outlines of both valves, as in some species the left and right valves display a slight asymmetry. Additionally, the details of the inner lamella have to be documented even if these structures are not preserved in many specimens. Despite these limitations and maybe also because our treatment of this complicated project is incomplete, we suggest that our colleagues try the recipes and the algorithms we offer here.

We conclude this digression within the field of descriptive morphology and systematics with a short statement made by a well-known Austrian biologist, G. Schatz, who started his career at the University of Graz and ended it as President of the Swiss Science and Technology Council: "*Scientific exploration is an expedition into the unknown – just like good art. The greater a scientific or artistic innovation, the more it surprises us.*" (cf. Schatz 2006: 113). We hope that for the near future the developments presented here will awake the interest of a wider spectrum of ostracodologists for geometric morphometrics, an exciting domain of research.

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Annex 1: Data lists

No.	Sampling Site	Sample Type	Sediment Layer	Valve No.	Label
1	SM	Bs	16	3471	3471AMPL2_fRSM16
2	HD	Bs	Nz	3581	3581AMPL_RVHDNZ
3	HD	Bs	Nz	3582	3582AMPL_RVHDNZ
4	HD	Bs	Nz	3583	3583AMPL_mRVHDNZ
5	HD	Bs	Nz	3584	3584AMPL_RVHDNZ
6	HD	Bs	V	3829	3829AMPL_RVHDV
7	HD	Bs	Eα	3849	3849AMPL_RVHDEA
8	HD	Bs	D	7316	7316AMPL_RVHD
9	HD	Bs	D	7318	7318AMPL_RVHD
10	HD	Bs	D	7319	7319AMPL_RVHD
11	HD	Bs	D	7320	7320AMPL_RVHD
12	HD	Bs	D	7321	7321AMPL_RVHD
13	HD	Bs	K	7323	7323RvHD-K
14	HD	Bs	K	7328	7328RvHDK
15	HD	Bs	K	7329	7329RvHDK
16	HD	Bs	R	7331	7331RvHD-R
17	HD	Bs	Q	7335	7335RvHD-Q
18	HD	Bs	Q	7337	7337RvHD-Q
19	HD	Bs	Q	7338	7338RvHD-Q
20	HD	Co-6	1.5-2	7339	7339AMPLRv.HD. C6. L1,5
21	HD	Co-6	1.5-2	7341	7341AMPL Rv.HD.C6.L1.5
22	HD	Bs	Ny	7342	7342RvHD-NYm
23	HD	Bs	B	7354	7354Rv
24	HD	Bs	E	7356	7356Rv
25	HD	Bs	G	7359	7359RvHD-G
26	HD	Bs	H	7361	7361RvHD-H
27	HD	Bs	I	7364	7364RvHD-I
28	HD	Bs	I	7365	7365RvHD-I
29	HD	Bs	O	7369	7369RvHD-O
30	HD	Bs	O	7370	7370RvHD-O
31	HD	Bs	O	7371	7371RvHD-O
32	HD	Bs	Ny	7373	7373RvHD-NY
33	HD	Bs	Ny	7374	7374RvHD-NY
34	HD	Bs	Mα	7378	7378RvHD-MA
35	HD	Bs	Mα	7379	7379RvHD-MA
36	HD	Bs	Mα	7380	7380Rv
37	HD	Bs	Mα	7382	7382RvHD-MA
38	HD	Bs	Mα	7384	7384RvHD-MA
39	HD	Bs	Q	7942	7942
40	HD	Co-6	0-0.5	8033	8033, RV, HD
41	HD	Co-6	0-0.5	8034	8034, RV, HD
42	HD	Co-6	0-0.5	8036	8036, RV, HD
43	HD	Co-6	0-0.5	8037	8037, RV, HD
44	HD	Co-6	0-0.5	8038	8038, RV, HD
45	HD	Co-6	1-1.5	8039	8039, RV, HD
46	HD	Co-6	2-2.5	8041	8041, RV, HD
47	HD	Co-6	2-2.5	8042	8042, RV, HD
48	HD	Co-6	3-3.5	8043	8043, RV, HD
49	HD	Co-6	3-3.5	8044	8044, RV, HD
50	HD	Co-6	3.5-4	8045	8045, RV, HD
51	HD	Co-6	3.5-4	8046	8046, RV, HD

Tab. 1: General information on *Amplocypris* material. Sampling Site: HD – Hennersdorf; SM – St. Margarethen; S (ÖD) – Sopron (= Ödenburg), Reuss material; TU – Soceni, Turislav valley. Sample Type: Bs – Bulk sample; Co-6 – Core No. 6. Sediment Layer: 16 – cf. lithologic profile of the St. Margarethen section in Buttinger 2008, Fig. 7; B, D, E, G, H, I, K, Ny, Nz, O, Q, R, V, Eα, Mα – sediment layers, cf. lithologic profile of the Hennersdorf section, Fig. 6, left side; 0–0.5… – depth position of half centimetre layers in Core 6; 5 – pertains to layer 5 of the lithologic profile Soceni, Turislav valley section, unpublished data. Valve No.: corresponds to the material photographed and stored in the collection of the Universalmuseum Joanneum (all items are right valves, excepting No. 91 and 100, left valve). Label: pertains to the files used for the morphometric processing of the ostracod material. Additional information see text.

52	HD	Co-6	3.5-4	8047	8047, RV, HD
53	HD	Co-6	3.5-4	8048	8048, RV, HD
54	HD	Co-6	4.5-5	8049	8049, RV, HD
55	HD	Co-6	5-5.5	8050	8050, RV, HD
56	HD	Co-6	5-5.5	8051	8051, RV, HD
57	HD	Co-6	6.5-7	8052	8052, RV, HD
58	HD	Co-6	7-7.5	8053	8053, RV, HD
59	HD	Co-6	7.5-8	8054	8054, RV, HD
60	HD	Co-6	7.5-8	8055	8055, RV, HD
61	HD	Co-6	7.5-8	8056	8056, RV, HD
62	HD	Co-6	9.5-10	8057	8057, RV, HD
63	HD	Co-6	9.5-10	8058	8058, RV, HD
64	HD	Co-6	9.5-10	8059	8059, RV, HD
65	HD	Co-6	9.5-10	8060	8060, RV, HD
66	HD	Co-6	9.5-10	8061	8061, RV, HD
67	HD	Co-6	9.5-10	8062	8062, RV, HD
68	HD	Co-6	9.5-10	8063	8063, RV, HD
69	HD	Co-6	9.5-10	8064	8064, RV, HD
70	HD	Co-6	10-10.5	8065	8065, RV, HD
71	HD	Co-6	10-10.5	8066	8066, RV, HD
72	HD	Co-6	11.11.5	8067	8067, RV, HD
73	HD	Co-6	16-16.5	8068	8068, RV, HD, C6, L16-16,5
74	HD	Co-6	16.5-17	8069	8069, RV, HD, C6, L16,5,-17
75	HD	Co-6	17-17.5	8072	8072, RV, HD, C6, L17-17,5
76	HD	Co-6	18-18.5	8073	8073, RV, HD, C6, L18-18,5
77	HD	Co-6	19.5-20	8074	8074, RV, HD, C6, L19,5-20
78	HD	Co-6	20.5-21	8075	8075, RV, HD, C6, L20,5-21
79	HD	Co-6	23.5-24	8076	8076, RV, HD, C6, L23,5-24
80	HD	Co-6	24-24.5	8077	8077, RV, HD, C6, L24-24,5
81	HD	Co-6	24.5-25	8079	8079, RV, HD, C6, L24,5-25
82	HD	Co-6	26-26.5	8081	8081, RV, HD, C6, L26-26,5
83	HD	Co-6	26.5-27	8082	8082, RV, HD, C6, L26,5-27
84	HD	Co-6	27.5-28	8086	8086, RV, HD, C6, L27,5-28
85	HD	Co-6	27.5-28	8087	8087, RV, HD, C6, L27,5-28
86	HD	Co-6	28-28.5	8088	8088, RV, HD, C6, L28-28,5
87	HD	Co-6	28.5-29	8090	8090, RV, HD, C6, L28,5-29
88	HD	Co-6	28.5-29	8091	8091, RV, HD, C6, L28,5-29
89	HD	Co-6	28.5-29	8093	8093, RV, HD, C6, L28,5-29
90	HD	Co-6	27-27.5	8150	8150, RV, HD, C6, L27-27,5
91	HD	Bs	Mα	7381*	7381, HD LV
92	S(ÖD)	Bs	-	7443	7443ÖD
93	S(ÖD)	Bs	-	7444	7444ÖD
94	S(ÖD)	Bs	-	7445	7445ÖD
95	S(ÖD)	Bs	-	7892	7892ÖD
96	S(ÖD)	Bs	-	7896	7896ÖD
97	S(ÖD)	Bs	-	7899	7899ÖD
98	S(ÖD)	Bs	-	10Ra	10Ra ÖD
99	S(ÖD)	Bs	-	12Ri	12Ri ÖD
100	S(ÖD)	Bs	-	6LV*	6LV ÖD
101	TU	Bs	5	3593	3593TUR5
102	TU	Bs	5	3592	3592TUR5

Tab. 1: (continued) General information on *Amplocypris* material.

Amplocypris VariablesData Set N-101 (22.04.2011)

Valve-Labels	H	Cv10	Cm1	Cd2	Cd9	Cm2	Cv2
3471AMPL2_fRSM16	92.34	97.93	96.66	83.32	71.98	98.92	96.84
3581AMPL_RVHDNZ	102.75	104.85	95.3	85.82	75.28	100.29	97.22
3582AMPL_RVHDNZ	102.16	101.83	96.07	85.87	75.54	100.39	96.6
3583AMPL_mRVHDNZ	100	100.23	97.25	86.33	75.16	100.98	96.92
3584AMPL_RVHDNZ	100.69	102.27	95.57	84.65	74.91	100.39	96.69
3592AMPL_fRVTUR5	103.54	106.39	92.93	84.9	76.14	98.14	96.4
3593AMPL_fRVTUR5	105.3	107.26	95.09	85.76	76.35	98.82	98.26
3829AMPL_RVHDV	104.71	100.75	96.27	86.01	75.61	99.61	97.05
3849AMPL_RVHDEA	98.63	99.52	95.5	84.29	72.93	100.1	95.9
7316AMPL_RVHD	95.29	105.77	93.92	82.35	72.24	98.04	94.05
7318AMPL_RVHD	96.36	106.48	93.61	82.9	73.1	98.23	93.73
7319AMPL_RVHD	95.29	106.08	93.92	82.23	72.43	98.33	93.56
7320AMPL_RVHD	98.14	100.76	96.17	84.91	75.47	100.39	96.09
7321AMPL_RVHD	100.49	102.01	95.19	85.1	73.89	100.69	97.59
7323RvHD-K	102.26	102.28	96.17	85.78	74.46	100.29	97.54
7328RvHDK	98.14	102.65	96.37	84.1	73.62	99.41	96.92
7329RvHDK	97.45	101.25	96.27	84.5	77.77	100.3	96.21
7331RvHD-R	98.14	102.48	95.98	84.23	74.43	99.71	96.57
7335RvHD-Q	101.77	102.31	95.09	84.44	74.74	100.2	97.67
7337RvHD-Q	101.86	101.47	96.56	85.65	74.8	100.49	96.97
7338RvHD-Q	102.16	100.5	96.66	85.51	74.96	100.79	96.31
7339AMPLRv.HD. C6. L1,5	97.75	101.95	96.18	84.12	72.94	99.8	96.67
7341AMPL Rv.HD.C6.L1.5	97.64	101.5	96.66	84.68	74.16	100.29	96.71
7342RvHD-NYm	108.27	105.33	95.67	86.61	76.66	100.29	99.14
7354Rv	99.61	107.63	92.16	82.79	73.75	97.15	94.29
7356Rv	97.84	107.33	93.5	83.49	73.29	97.74	94.29
7359RvHD-G	100.59	102.6	96.46	84	73.86	99.51	96.53
7361RvHD-H	96.57	100.28	95.98	84.97	73.58	99.61	95.93
7364RvHD-I	96.46	100.22	96.66	86.37	74.36	100.89	97.32
7365RvHD-I	100.89	102.99	95.97	85.39	73.93	99.61	97.52
7369RvHD-O	100	100.63	96.86	85.45	73.95	100.59	96.44
7370RvHD-O	99.61	102.51	95.48	84.37	73.25	100	97.06
7371RvHD-O	99.12	102.65	94.42	82.89	73.09	99.9	97.22
7373RvHD-NY	101.87	104.73	95.78	83.98	74.77	98.92	96.01
7374RvHD-NY	104.9	105.15	95.69	86	75.61	99.8	98.2
7378RvHD-MA	101.18	102.02	94.9	84.39	74.18	99.61	96.33
7379RvHD-MA	96.37	101.37	96.37	85.78	74.23	100.49	95.91
7380Rv	95.78	106.22	94.01	82.61	71.7	98.23	94.24
7382RvHD-MA	100.19	100.84	96.27	85.01	74.02	100.29	97.41
7384RvHD-MA	99.8	101.77	96.08	84.95	75.02	100.29	96.94
7443RvÖD	96.28	103.39	93.54	82.25	72.94	99.61	96.05
7444RvÖD	94.52	102.94	93.93	81.26	71.58	99.31	95.69
7445RvÖD	98.72	104.57	93.82	81.68	71.53	98.82	97.14
7892RVÖD	101.67	104.37	94.2	83.08	73.8	99.41	97.39
7896RVÖD	100.2	101.56	95.49	84.33	74.15	100	98.79
7899RVÖD	99.51	103.11	94.6	84.42	74.42	99.9	97.92
7942	100.88	102.78	96.17	84.16	74.39	99.12	95.98
8033, RV, HD	102.95	101.29	97.05	85.86	75.27	100.39	96.12
8034, RV, HD	94.6	99.93	96.37	84.35	73.15	100.39	95.31
8036, RV, HD	98.03	101.05	96.06	86.1	75.25	100.79	96.09
8037, RV, HD	97.94	100.28	95.98	85.28	75.91	101.57	95.79

Tab. 2: Morphometric data for the variables H, Cv10, Cm1, Cd2, Cd9, Cm2 and Cv2 (length in mm, cf. text).

8038, RV, HD	98.82	101.81	95.69	85.69	75.19	100.69	96.69
8039, RV, HD	100.98	102.49	96.07	85.43	75	100.88	97.27
8041, RV, HD	97.15	100.76	96.17	84.73	73.89	100.98	96.4
8042, RV, HD	100.88	101.53	96.77	85.17	74.51	100	96.92
8043, RV, HD	99.12	100.97	96.18	85.24	74.58	100.1	95.84
8044, RV, HD	99.31	100.64	96.37	85.6	73.92	100.39	96.74
8045, RV, HD	100.39	100.18	96.27	86.96	74.53	100.98	97.66
8046, RV, HD	97.35	102.53	95.78	83.85	73.48	99.8	96.26
8047, RV, HD	100.39	101.41	95.88	84.64	73.51	100.2	98.24
8048, RV, HD	95.4	99.83	96.96	84.74	73.45	100.49	95.93
8049, RV, HD	95.4	101.05	95.8	83.32	72.94	99.71	96.44
8050, RV, HD	99.22	101.56	96.47	85.82	74.59	100.39	96.55
8051, RV, HD	98.24	101.65	94.91	84.91	75.01	99.9	96.65
8052, RV, HD	98.42	101.9	96.46	84.87	74.74	100.59	96.33
8053, RV, HD	100.01	100.96	96.07	85.6	73.86	100.6	96.79
8054, RV, HD	98.33	99.36	97.35	86.65	74.06	101.18	96.77
8055, RV, HD	101.79	100.36	96.86	86.17	74.4	100.3	96.95
8056, RV, HD	97.45	101.97	95.69	84.51	74.08	99.41	95.61
8057, RV, HD	98.43	100.99	95.48	84.63	74.24	100.98	96.61
8058, RV, HD	97.45	100.37	96.46	85.36	74.01	100.2	95.91
8059, RV, HD	98.53	98.89	96.57	86.09	75.16	100	95.68
8060, RV, HD	98.33	99.54	96.57	86.03	74.56	100.69	97.16
8061, RV, HD	97.55	101.17	96.76	85.22	73.86	100.2	96.49
8062, RV, HD	102.07	103.02	95.38	85.57	74.34	100.1	98.4
8063, RV, HD	99.99	101.09	95.28	84.56	74.09	100.2	96.85
8064, RV, HD	98.14	103.23	95.01	84.13	72.78	100.39	97.54
8065, RV, HD	100	101.98	95.87	84.19	74.23	100.2	97.47
8066, RV, HD	101.18	101.94	96.46	84.68	74.37	99.16	96.67
8067, RV, HD	97.27	100.33	96.68	86.27	74.43	100.2	95.31
8068, RV, HD, C6, L16-16,5	101.37	101.59	95.49	85.27	75.12	100.39	97.43
8069, RV, HD, C6, L16,5,-17	104.71	104.65	96.27	86.34	75.24	100	97.23
8072, RV, HD, C6, L17-17,5	101.37	104.42	95.7	84.38	73.56	99.03	97.41
8073, RV, HD, C6, L18-18,5	105.19	104.29	95.79	85.74	75.53	99.41	97.71
8074, RV, HD, C6, L19,5-20	98.53	104.69	95.39	85.16	75.03	99.61	96.3
8075, RV, HD, C6, L20,5-21	103.35	105.24	96.06	86.03	75.56	100	96.95
8076, RV, HD, C6, L23,5-24	101.18	101.69	96.27	84.52	73.61	100.6	96.78
8077, RV, HD, C6, L24-24,5	100.89	104.92	95.97	86.69	75.48	100.29	97.73
8079, RV, HD, C6, L24,5-25	103.04	106.16	94.03	84.56	74.75	99.41	97.9
8081, RV, HD, C6, L26-26,5	100.69	101.62	96.37	84.98	73.68	99.9	97.96
8082, RV, HD, C6, L26,5-27	97.84	101.45	96.27	84.62	73.72	99.51	95.79
8086, RV, HD, C6, L27,5-28	101.66	104.94	95.73	83.59	73.59	100.38	97.89
8087, RV, HD, C6, L27,5-28	96.57	100.5	95.78	83.73	73.62	99.8	96.26
8088, RV, HD, C6, L28-28,5	103.53	106.03	94.51	85.01	75.49	99.41	97.53
8090, RV, HD, C6, L28,5-29	102.16	103.29	96.66	85.92	74.68	98.72	98.48
8091, RV, HD, C6, L28,5-29	99.41	100.3	96.07	85.18	74.36	100.39	97.09
8093, RV, HD, C6, L28,5-29	105.99	103.58	96.17	86.29	76.73	100.1	97.29
8150, RV, HD, C6, L27-27,5	103.64	108.07	95.38	85.01	74.65	99.21	97.35
AmploabscissaLectotypeRVev	99.21	104.84	92.82	81.91	72.61	97.64	96.72
AmloabscissaRVivTurnovsky	97.05	105.74	94.89	82.75	75.39	96.96	95.02
Amploabscissa Fig 2 Reuss	92.64	105.56	93.03	84.01	71.87	98.14	95.84

Tab. 2: (continued) Morphometric data for the variables H, Cv10, Cm1, Cd2, Cd9, Cm2 and Cv2 (length in mm, cf. text).

Amplocypris VariablesData Set N-99
(including variables Angv10, pi, L) (22.04.2011)

	Ang V10	pi	L
3471AMPL2_fRSM16	127	32.39	1.43
3581AMPL_RVHDNZ	90	18.75	1.48
3582AMPL_RVHDNZ	106	26.67	1.38
3583AMPL_mRVHDNZ	112	30.15	1.38
3584AMPL_RVHDNZ	106	25.33	1.38
3829AMPL_RVHDV	114	28.21	1.38
3849AMPL_RVHDEA	107	32.39	1.43
7316AMPL_RVHD	77	12.66	1.54
7318AMPL_RVHD	77	11.9	1.6
7319AMPL_RVHD	75	10.08	1.54
7320AMPL_RVHD	110	25.71	1.33
7321AMPL_RVHD	108	22.12	1.25
7323RvHD-K	110	25.35	1.33
7328RvHDK	107	25.71	1.33
7329RvHDK	108	25.71	1.33
7331RvHD-R	105	26.09	1.33
7335RvHD-Q	106	25.33	1.38
7337RvHD-Q	106	27.27	1.43
7338RvHD-Q	108	27.63	1.33
7339AMPLRv.HD. C6. L1,5	111	25.71	1.33
7341AMPL Rv.HD.C6.L1.5	109	27.14	1.33
7342RvHD-NYm	97	22.63	1.43
7354Rv	73	8.33	1.48
7356Rv	78	11.02	1.54
7359RvHD-G	108	25.71	1.25
7361RvHD-H	109	26.47	1.25
7364RvHD-I	109	28.57	1.33
7365RvHD-I	103	22.06	1.25
7369RvHD-O	107	27.63	1.38
7370RvHD-O	106	24.32	1.33
7371RvHD-O	99	24.66	1.38
7373RvHD-NY	91	17.52	1.48
7374RvHD-NY	93	17.22	1.48
7378RvHD-MA	105	25	1.43
7379RvHD-MA	113	28	1.43
7380Rv	77	13.93	1.48
7382RvHD-MA	109	27.82	1.33
7384RvHD-MA	105	26.39	1.33
7942	104	22.97	1.33
8033, RV, HD	110	28.75	1.48
8034, RV, HD	108	29.7	1.21
8036, RV, HD	108	26.47	1.25
8037, RV, HD	110	28.57	1.33
8038, RV, HD	104	27.69	1.25
8039, RV, HD	107	26.09	1.18
8041, RV, HD	112	30.56	1.21
8042, RV, HD	112	29.17	1.33
8043, RV, HD	105	26.76	1.33
8044, RV, HD	106	28.57	1.29
8045, RV, HD	112	31.43	1.29
8046, RV, HD	103	27.14	1.29
8047, RV, HD	108	28.17	1.25
8048, RV, HD	111	31.88	1.29
8049, RV, HD	110	27.54	1.33
8050, RV, HD	106	28.17	1.33
8051, RV, HD	108	26.76	1.29
8052, RV, HD	104	27.03	1.33
8053, RV, HD	112	27.94	1.38
8054, RV, HD	112	31.43	1.25
8055, RV, HD	112	29.73	1.29
8056, RV, HD	105	25.71	1.33
8057, RV, HD	107	26.76	1.33
8058, RV, HD	110	28.99	1.29
8059, RV, HD	118	30	1.33
8060, RV, HD	110	31.88	1.29
8061, RV, HD	112	28.77	1.33
8062, RV, HD	103	24.64	1.18
8063, RV, HD	110	26.32	1.33
8064, RV, HD	105	23.29	1.33
8065, RV, HD	104	27.4	1.33
8066, RV, HD	109	27.14	1.29
8067, RV, HD	112	30	1.33
8068, RV, HD, C6, L16-16,5	105	27.63	1.33
8069, RV, HD, C6, L16,5,-17	91	20.99	1.33
8072, RV, HD, C6, L17-17,5	91	19.48	1.33
8073, RV, HD, C6, L18-18,5	92	20	1.43
8074, RV, HD, C6, L19,5-20	85	17.57	1.33
8075, RV, HD, C6, L20,5-21	90	18.52	1.43
8076, RV, HD, C6, L23,5-24	108	26.32	1.33
8077, RV, HD, C6, L24-24,5	90	21.52	1.43
8079, RV, HD, C6, L24,5-25	85	12.99	1.33
8081, RV, HD, C6, L26-26,5	106	26.39	1.33
8082, RV, HD, C6, L26,5-27	106	25.71	1.29
8086, RV, HD, C6, L27,5-28	91	15.66	1.43
8087, RV, HD, C6, L27,5-28	106	27.14	1.29
8088, RV, HD, C6, L28-28,5	90	15.85	1.43
8090, RV, HD, C6, L28,5-29	105	24.32	1.33
8091, RV, HD, C6, L28,5-29	108	28.77	1.33
8093, RV, HD, C6, L28,5-29	97	19.23	1.33
8150, RV, HD, C6, L27-27,5	79	8.75	1.43
7443ÖD	92	15.87	1.48
7444ÖD	93	18.4	1.43
7445ÖD	90	15.5	1.54
7892ÖD	93	17.56	1.43
7896ÖD	108	24.64	1.21
7899ÖD	93	17.19	1.43
3593TUR5	81	11.34	1.78
3592TUR5	84	11.83	1.67
AmploabscissaLectotypeRVev	93	16.04	1.48

Tab. 3: Morphometric data for the additional variables L, Ang-V10 and pi (cf. text for the way they are defined and measured).

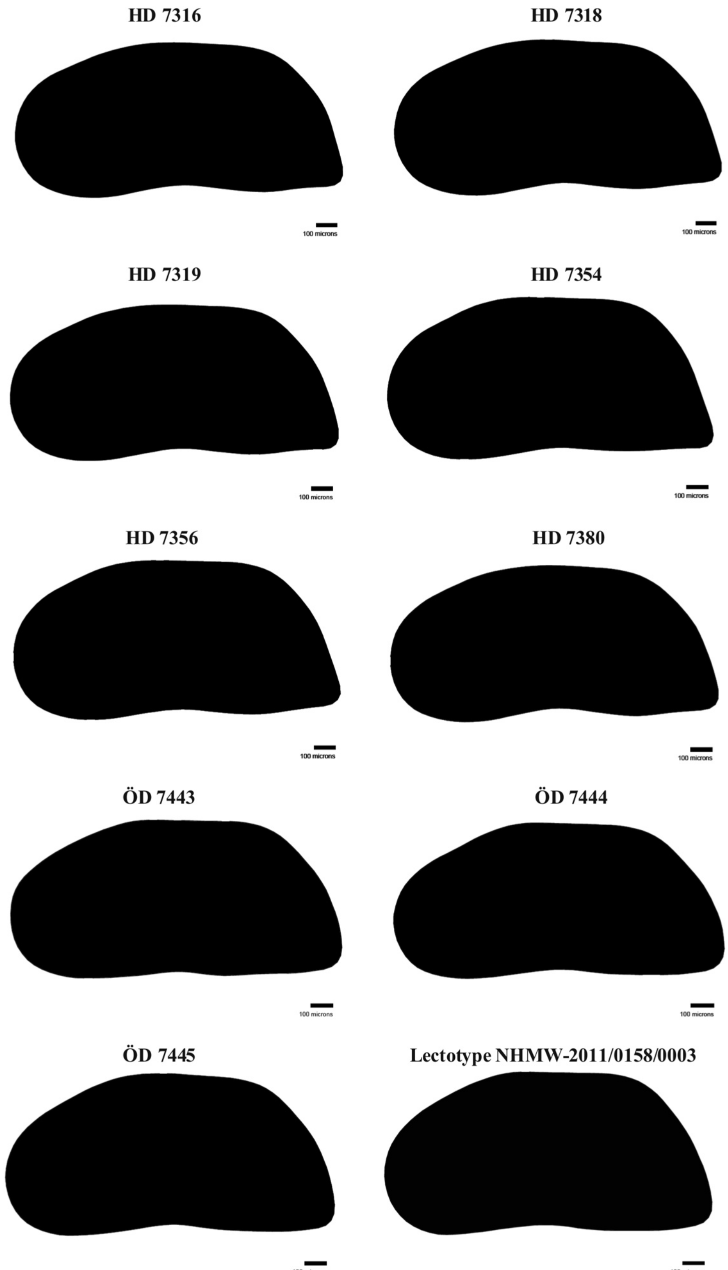
Amplocypris abscissa (Reuss)	N	H	Cv10	Cm1	Cd2	Cd9	Cm2	Cv2	Ang-V10 (°)	pi - h/H (%)	L
Morphotype a*bscissa*	9										
Arithmetic Mean		96.39	105.73	93.57	82.48	72.63	98.33	94.49	80.26	12.76	1.51
Confidence Limits 99%		95.23-97.94	104.27-106.93	92.96-93.93	81.92-82.98	72.01-73.24	97.72-99.02	93.85-95.30	75.22-88.33	10.27-15.56	1.47-1.55
Range Range		94.52-99.61	102.94-107.63	92.16-94.01	81.26-83.49	71.53-73.75	97.15-99.31	93.56-97.14	73-93	8.33-18.4	1.43-1.6
Morphotype q*uasi-abscissa*	20										
Arithmetic Mean		102.97	104.96	95.36	85.24	75.1	99.6	97.47	90.71	17.72	1.42
Confidence Limits 99%		101.71-104.37	104.34-105.67	94.83-95.81	84.64-85.82	74.6-75.62	99.24-99.93	97.05-97.9	87.45-94.2	15.46-19.82	1.38-1.49
Range		98.53-108.27	103.11-108.07	92.93-96.66	83.08-86.69	73.56-76.73	98.14-100.38	96.01-99.14	79-105	8.75-24.32	1.33-1.78
Morphotype r*otunda*	68										
Arithmetic Mean		99.28	101.31	96.11	85.05	74.31	100.24	96.68	107.97	27.28	1.32
Confidence Limits 99%		98.6-99.91	100.99-101.61	95.94-96.29	84.79-85.31	74.07-74.58	100.09-100.4	96.48-96.89	107.03-108.98	26.28-27.96	1.30-1.34
Range		94.6-104.71	98.89-103.23	94.42-97.35	82.89-86.96	72.78-77.77	99.12-101.57	95.31-98.79	99-118	22.06-32.39	1.18-1.48
Amplocypris recta (Reuss)	1	92.34	97.93	96.66	83.32	71.98	98.92	96.84	127	32.39	1.43

Tab. 4: Arithmetic mean and 99 % Confidence Limits (CL) around the mean for each variable of *Amplocypris abscissa* morphotypes and for *Amplocypris recta* (cf. text): N – number of valves for each morphotype category; the value of variables expressed in millimetres; for information on acronyms of the variables H, Cv10, Cm1, Cd2, Cd9, Cm2 and Cv2, L, Ang-V10 and pi, see text.

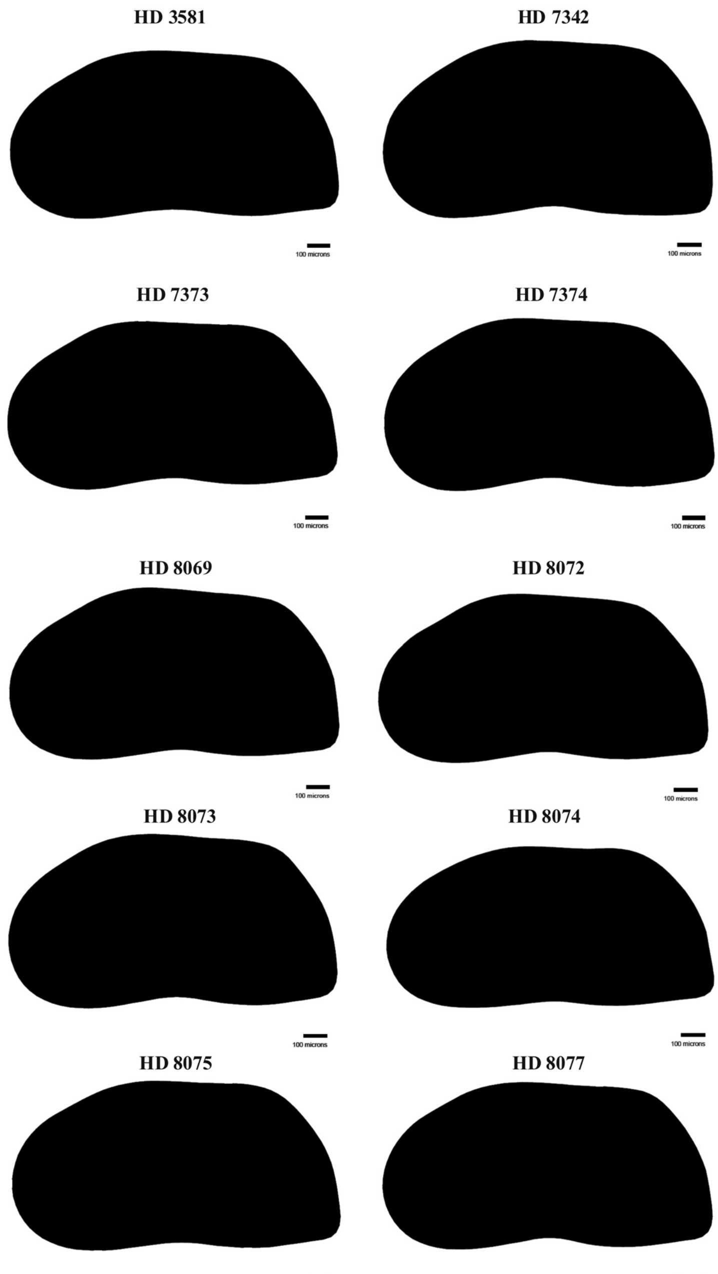
Annex 2

The *Amplocypris abscissa* valves grouped within the three morphotypes *abscissa*, *quasi*-*abscissa* and *rotunda* as well as the lectotype of *A. abscissa* and the St. Margarethen valve of *A. recta.*

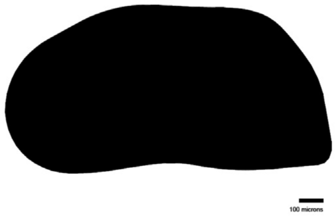
Morphotype *Abscissa*



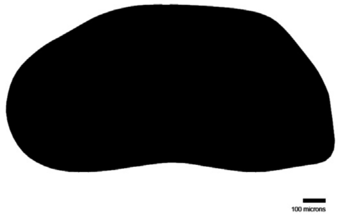
Morphotype *Quasi-abscissa*



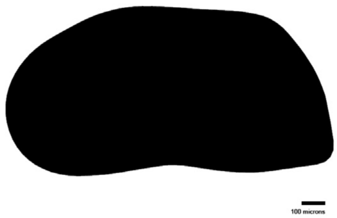
HD 8079



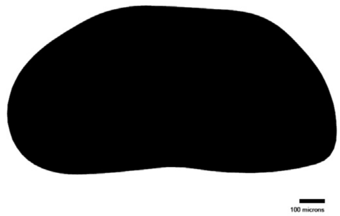
HD 8086



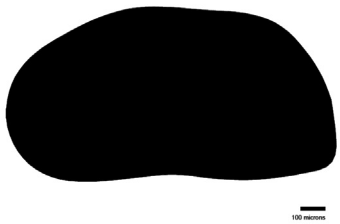
HD 8088



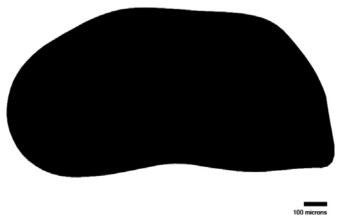
HD 8090



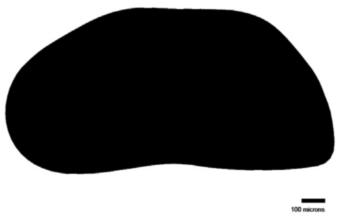
HD 8093



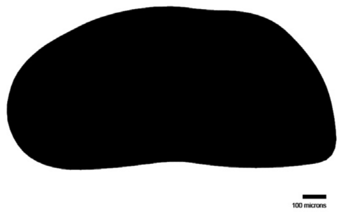
HD 8150



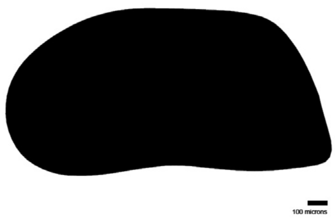
ÖD 7892



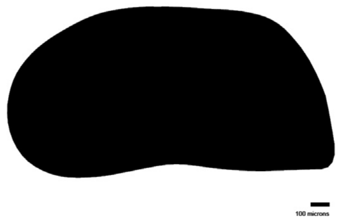
ÖD 7899



TU5 3592

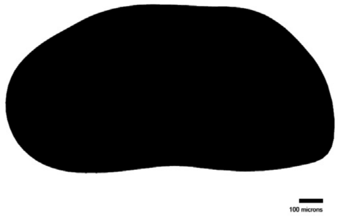


TU5 3593



Morphotype *Rotunda*

HD 3582



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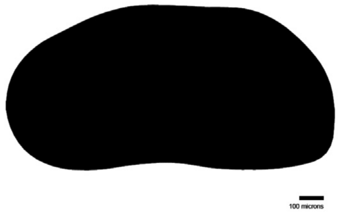

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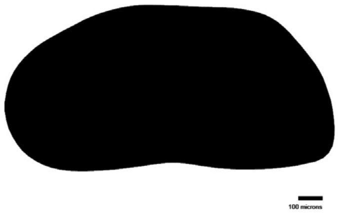

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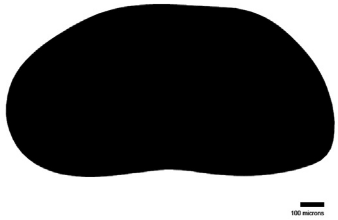
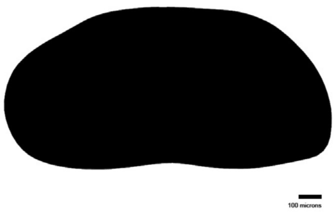
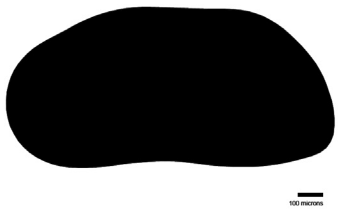


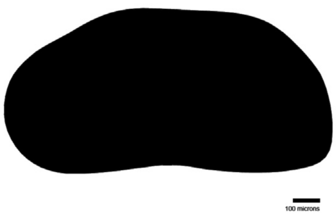
HD 3849



HD 7320



HD 7321



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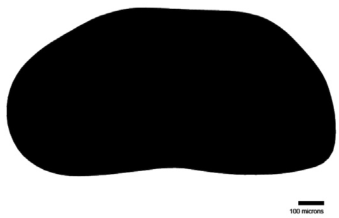
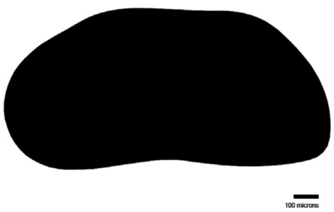
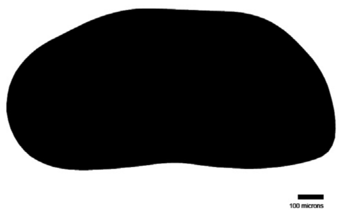


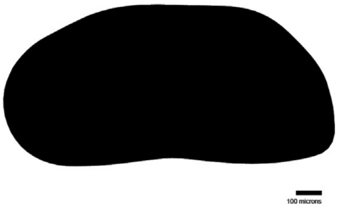
HD 7328



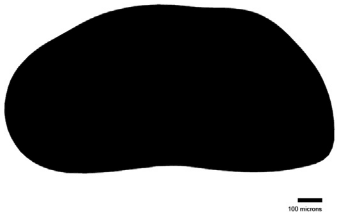
HD 7329



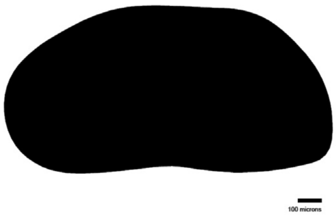
HD 7331



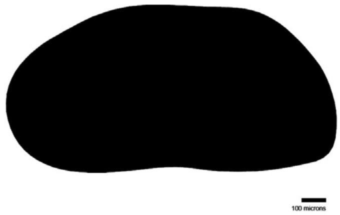
HD 7335



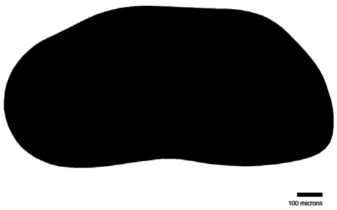
HD 7337



HD 7338



HD 7339



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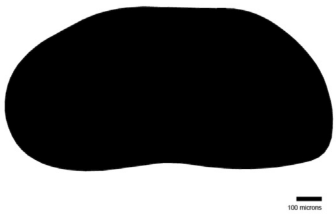
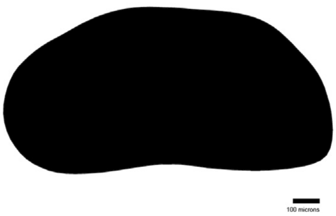


HD 7359



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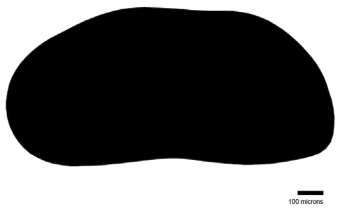

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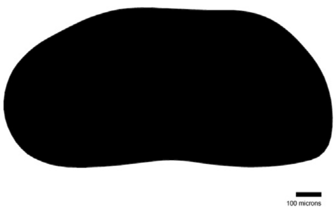

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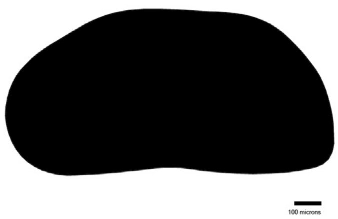

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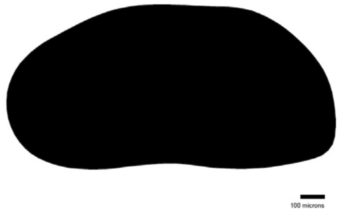

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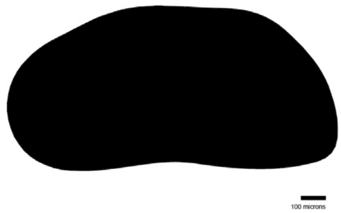

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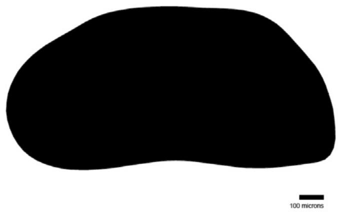

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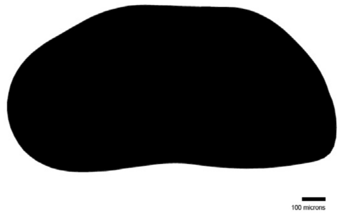
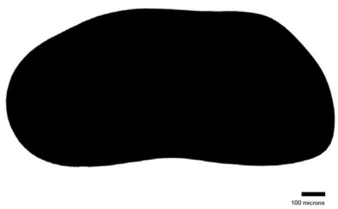


HD 7379



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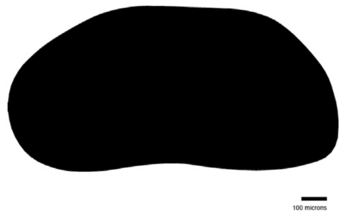

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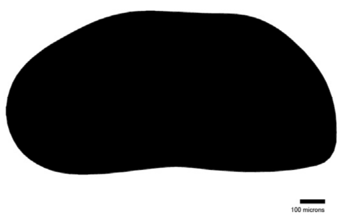
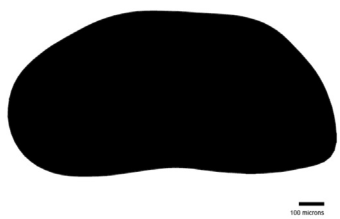
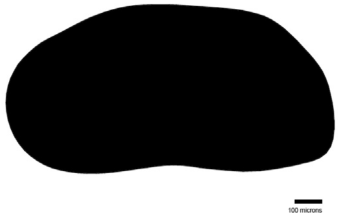


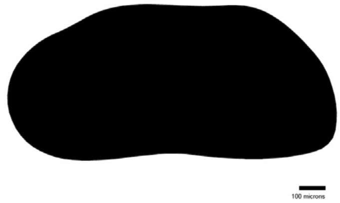
HD 7942



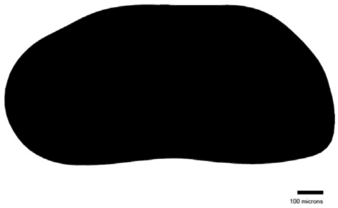
HD 8033



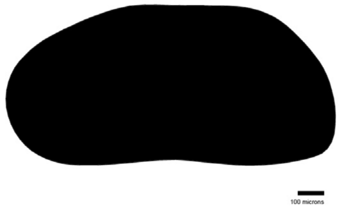
HD 8034



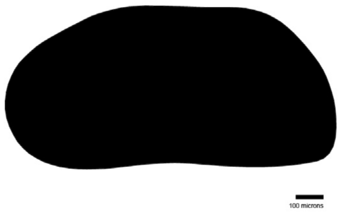
HD 8036



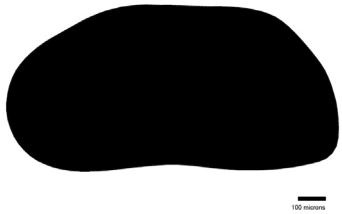
HD 8037



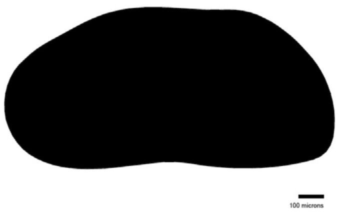
HD 8038



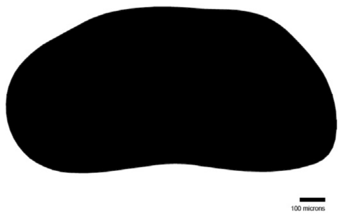
HD 8039



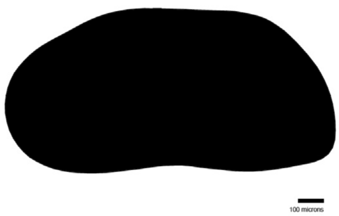
HD 8041



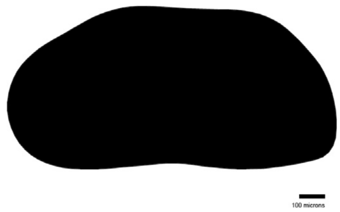
HD 8042



HD 8043



HD 8044



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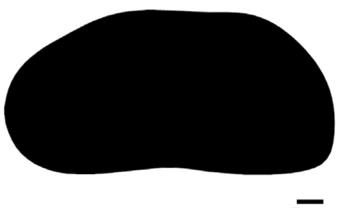
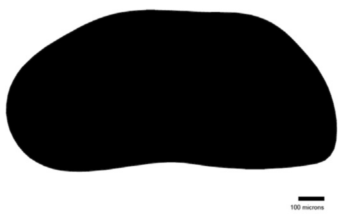
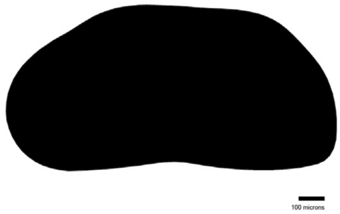


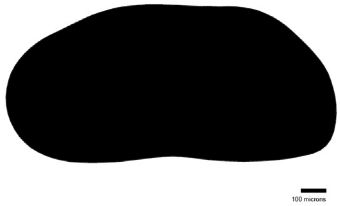
HD 8046



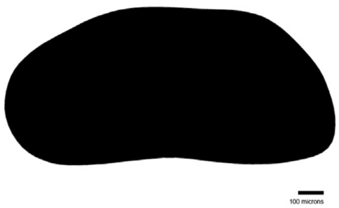
HD 8047



HD 8048



HD 8049



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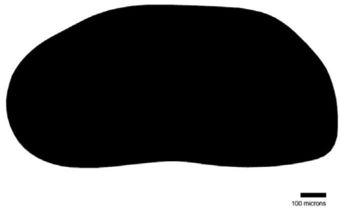

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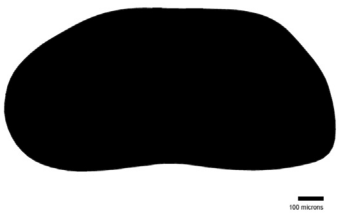

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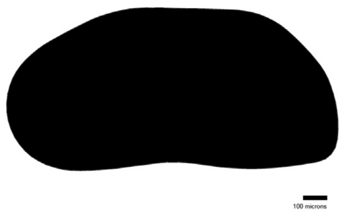

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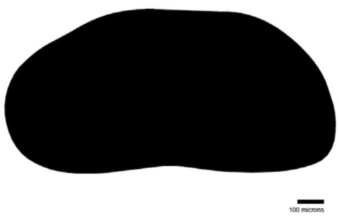

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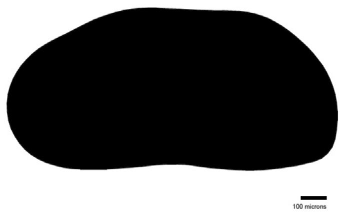

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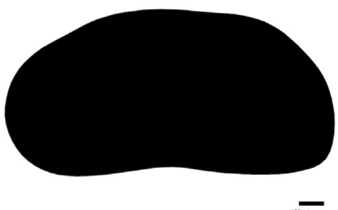

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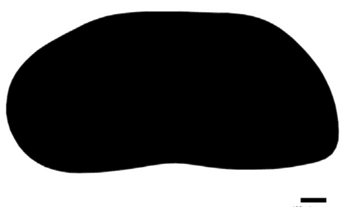

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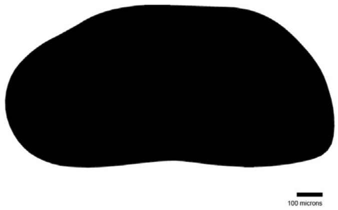

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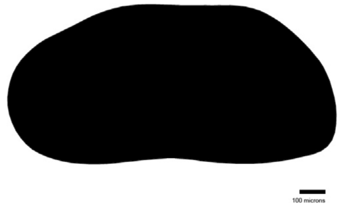

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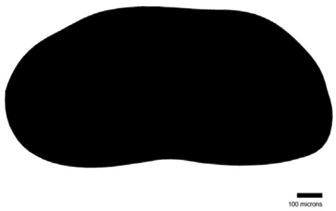

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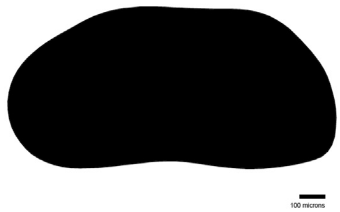

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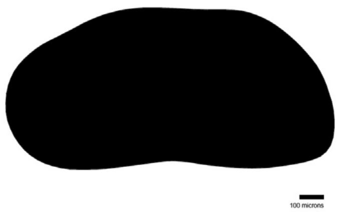

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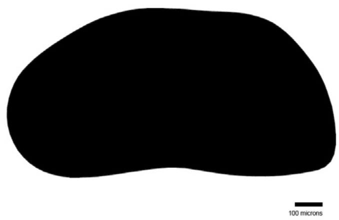

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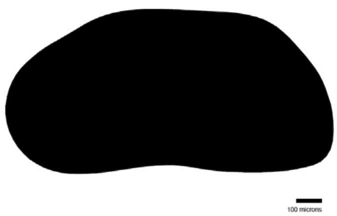

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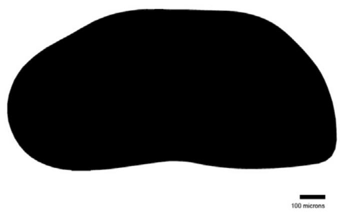

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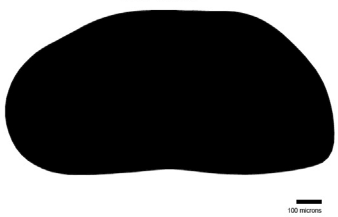

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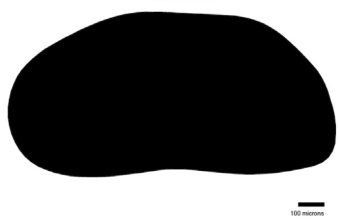

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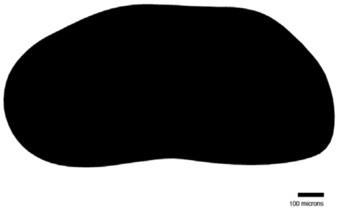

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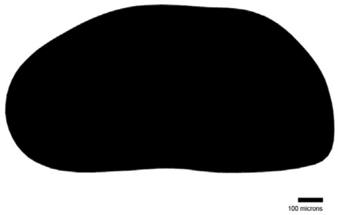

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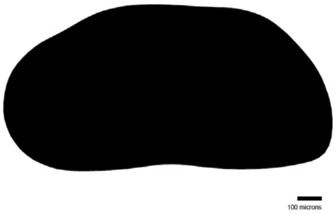

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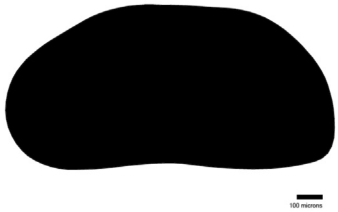

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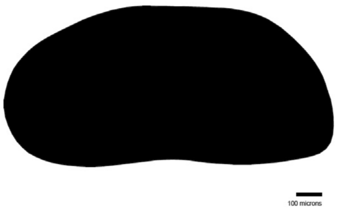

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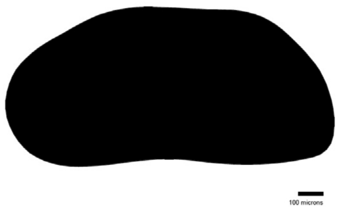

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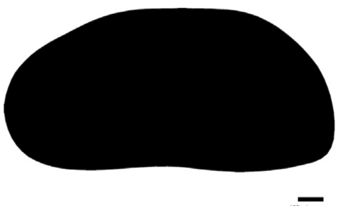

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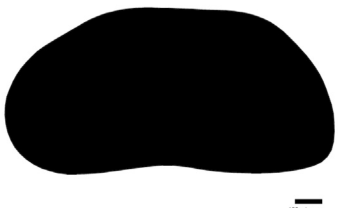

Morphotype *Amplocypris recta*

SM 3471